THE EFFECT OF DIFFERENT SOIL AMENDMENT ON IRRIGATION FREQUENCY, CROP YIELD, WATER USE EFFICIENCY OF SPINACH

G. Pragna[1], M.Jyothi[1], Neha Kunari[1], I. Bhaskar Rao[1]

[1]College of Agriculture Engineering, Bapatla

ABSTRACT: In coastal sandy soil water retention is poor and having high infiltration rate which results in the low yield. Soil amendment can be added to improve the water retention capacity and make water available at the root zone depth of crop and also improvises the crop yield significantly. This may decrease the amount of irrigation water hence thereby increases in irrigation interval. Field capacity was computed by field test method to decide the irrigation schedule. Two irrigation interval was selected i.e. 7 days irrigation interval and 10 days irrigation interval on the basis of 50% and 60% of soil moisture depletion as compared to the field capacity. Moisture retention in the soil is fundamental for crop growth and development. Soil water affects plant growth directly because it influences aeration, temperature, nutrient transport, uptake and transformation. Large pore spaces in sandy soils prevent water retention, make water dry out easily and escalates leaching of precious nutrients past plant roots, thus hindering plant growth.
Key words: Soil, Irrigation, Crop yield, Spinach

*Corresponding author: G. Pragna, College of Agriculture Engineering, Bapatla, India
guglothpragna@gmail.com

INTRODUCTION

Coastal ecosystem in India occupies an area of about 10.78 million hectares (107833 km^2). In India, coastal region covers the long strip along the east coast (West Bengal, Orissa, Andhra Pradesh, Pondicherry and Tamil Nadu) and West coast (Gujarat, Maharashtra, Karnataka and Kerala) (J. S. P. Yadav,1979) It also occupies considerable area under Lakshadweep, and Andaman and Nicobar. In Andhra Pradesh, total coastal region covers about 8.23 lakh ha consist of sandy loam and clay loam soil. Coastal sandy soil covers 61 ha, which is 9% of total area of Andhra Pradesh.(H.S. Gill and I. P. Abrol, 1990).

Crop yield was significantly affected by the application of the soil amendment like silt and aquasorb and showed an increment of 25% rise in the crop yield. The highest crop yield was obtained inSilt and aquasorb application and the lowest yield was found in control i.e only coastal sandy soil.10 days irrigation efficiency shows the significant higher water use efficiency than 7 days irrigation interval as a result we can save one irrigation.

Tank silt is fine granular material derived from rock or soil. It is a source of manure for crop production. It is also an organic amendment for improving water-use efficiency and productivity. The tank silt contains organic carbon, microbial biomass carbon, residual pesticides, etc., The sediment composition and depth of deposition vary from tank to tank silt with farm yard manure in different ratios effect on the soil physical properties like particle density, bulk density, porosity, water holding capacity. One of the best ways to improve soil hydraulic conductivity is, adding types of amendments such as super absorbent, vermin compost and silt to the soil.(RakeshTiwari 2014).

Aquasorbis Super Absorbent Polymers (SAP) which stores water in the upper horizons of the soil where plant roots are found. Significant reductions in irrigation requirements of many plants due to an increase in water holding capacity byaquasorb - amended soils have been reported.It increases the plant available water in the soil which prolongs plant survival under water stress. While irrigation is critical in overcoming water stress, the timing (which includes measurement of soil water, estimation of loss by evapotranspiration, and measurement of plant water status) is important. The low water holding capacity of sand soil causes rapid infiltration and deep percolation below the root zone. The use of gel-forming hydrophilic polymers (aquasorb) has been used to increase the water holding capacity of sandy soils. Ahmed A.,(1990), and L. O. Ekebafe et al.,(2011) in their respective studies on SAP. It has been found that SAP has extensive applications as reactive materials based on the potential advantages of the specific active functional groups and the characteristic properties of the polymeric molecules.

In coastal sandy soil water retention is poor and having high infiltration rate which results in the low yield. Soil amendment can be added to improve the water retention capacity and make water available at the root zone depth of crop and also improvises the crop yield significantly. This may decrease the amount of irrigation water hence thereby increases in irrigation interval. Therefore study was carried out to test the response of crop yield with different soil amendments.

The above mentioned constraints in coastal sandy soil leads for the study of the physical properties of soil, response of crop yield to the application of soil amendment.

1. Effect of application of soil amendment on soil moisture depletion curves
2. To study the relationship between moisture content and irrigation schedule
3. To study the water use efficiency and yield of spinach crop for different soil amendments.

MATERIALS AND METHODS

The experiment was conducted at College of Agricultural Engineering, Bapatla (latitude $15°53'20''$ and longitude $80°28'12''$). The mean annual rainfall in the region is 1167 mm. Out of total annual rainfall South west monsoon(June to September) accounts for 768 mm of rainfall, North east monsoon (October to December) accounts for 296 mm of rainfall , Winter (January to February) accounts for 17 mm of rainfall and Summer (March to May) accounts for 86 mm of rainfall.The soil texture in the region is sandy. The soil infiltration rate is 48 cm/h (Lai 1978). The average temperature throughout the year is $35°$ C and relative humidity is around 73%.

The possibility of reducing infiltration loss was evaluated in sandy soil. The experimental area of 0.19 acre was divided into 16 plots such that each plot has an area of 12.5 m^2 (5×2.5 m). The experimental design of the plots were carried out by factorial randomized block design (FRBD). The entire plots were applied with 11.96 t/ha farm yard manure (GogoneniVirendranath, 2013) as per recommendation. Current experiment began in February 2014 with the following four treatments.A completely factorial randomized design with 4 replicates for each treatment was used in this experiment. The primary factor included two irrigation intervals including irrigation at 7, 10 days and secondary factor included different composition like silt and super absorbent polymer (SAP).

Table 1. Different types of treatments

Treatment	Applicant	Quantity
T_1	Control	Control
T_2	Silt	168 t/ha
T_3	Super absorbent polymer	0.052 t/ha
T_4	Silt and super absorbent polymer	168 t/ha + 0.052 t/ha

Vagro green seed was selected for sowing in the experimental field. Each plot area is 5m x 2.5m out of which 2m x 2.5m area was taken for sowing and the remaining area was left for soil factor. Seeds were broadcasted at the rate of 130kg/ha. (Gogoneni virendranath.,2013)

Irrigation scheduling is done using the water balance method. The first step in scheduling is to calculate the soil water storage capacity (allowable depletion). To fine-tune allowable depletion of soil a hole was dugged and soil moisture was assed immediately before irrigation. The water storage in a soil must be balanced against plant water use. Plant water use is proportional to evaporation. Evaporation is effected by humidity and temperature.

Daily Crop water use(mm) = crop factor × daily evaporation(mm)

Soil water storage(mm)= allowable depletion - Daily Crop water use(mm)

Effective rainfall(mm)= total rainfall(mm) – irrigation given (mm)

Total soil water storage = soil water storage + effective rainfall

When the total soil water storage was 50% and 60% of field capacity then next irrigation was started. The two irrigation interval was maintained
1. At 7 days interval
2. At 10 days interval

The term water use efficiency denotes the production of crops per unit of water applied. It is expressed as the weight of crop produced per unit depth of water over a unit area i.e.kg/mm/ha. It is influenced by crop and soil management practices. The crop yield depends on the adequacy of the water supply. Most crops are sensitive to water stress at the critical phases of their growth. Water use efficiency can be increased either by increasing the crop yield or by decreasing the total amount used in the field. Required water was estimated from the amount of irrigation water supplied till the time of harvesting the spinach.

$$WUE = \frac{\text{Yield of the crop (kg/ha)}}{\text{Total amount of water used in the field (mm)}}$$

RESULTS AND DISCUSSIONS:
Field capacity for different treatments:
Field capacity of the soil in the experimental field was determined using the field method. There was a significant effect of silt and aquasorb application in the soil (fig 1). Increase in field capacity was observed in T_2(Silt application) compared with T_1(Control). Treatment T_4 (Silt and aquasorb application) showed the highest field capacity next to T_3 (aquasorb application).There was a variation about 10- 15% in the field capacity with the application silt whereas effect of aquasorb was around 20%. Combination of silt and aquasorb application gave the increment around 25% compared to the control i.e. only sandy soil.
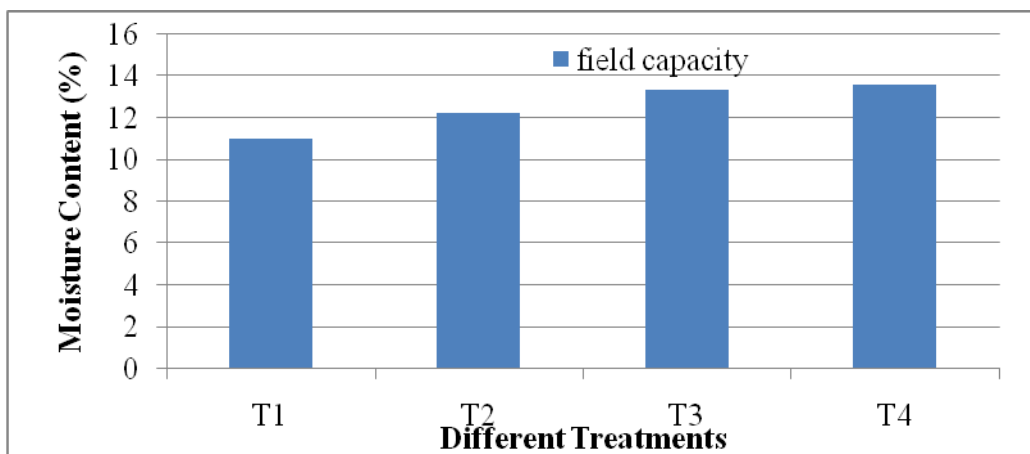

Fig 1. Field capacity on different tretments

Assessment of effect of irrigation trend on the moisture content of the soil
Irrigation was given at an interval of 7 days and 10 days and moisture was taken at the depth of 15cm and 30cm i.e. after reaching the 50% and 60% of field capacity. The experiment was replicated twice and average value of two replications was taken as data for reference.

Irrigation interval-I (7 days) at the depth of 0-15cm
Irrigation was given at an interval of 7 days and moisture was taken at the depth of 15cm i.e. after reaching the 50% of field capacity. Observation showed that first day after irrigation the moisture in T_4 was about 20% more than the T_1 whereas on the seventh day it was 40% more than the control, which signified the retention capacity of sandy soil was improved by application of silt andaquasorb**.** While the individual effect of the silt and the aquasorb is around 10-15% more than the control. The highest value of the moisture retention was obtained in the t4 (silt andaquasorb).The average value of moisture content of soil observed (fig 2) indicated that, there was a decrease in moisture content of the soil with passage of days after irrigation. The highest moisture retention capacity of the field was observed under T_4 (Silt and aquasorb application) and the least moisture retention capacity was observed under T_1 (Control). Treatment T_3 (aquasorb application) and T_2 (Silt application) showed highest moisture retention capacity next to T_4 (Silt and aquasorb application).
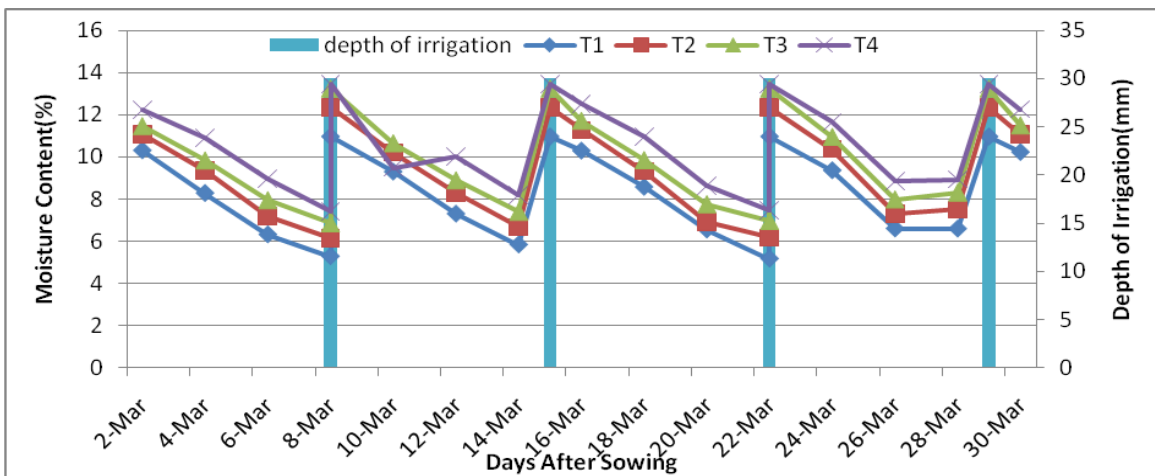
Fig 2. Irrigation interval-I (7 days) at 0-15 cm depth

Irrigation interval-I (7 days) at the depth of 15-30cm

Irrigation was given at an interval of 7 days and the moisture was taken at the depth of 30cm i.e. after reaching the 50% of field capacity. The experiment was replicated twice and average value of two replications was taken as data for reference. The initial moisture content of T_4 (Silt and aquasorb application) was 15% more than that of the control whereas on the seventh day after irrigation moisture retention of T_4 (Silt and aquasorb application) was 30% showed that the moisture retention at the depth of 15cm was more, as soil amendment was applied at a depth of 10cm. It was observed alone silt alone had increased the moisture retention about 10% than the control and aquasorb alone had effected also around 10% more than the control. There was a rise in moisture retention capacity in T_1(control) and T_2(silt application) compared with initial depth of 15cm. Whereas there is decrement of soil moisture retention in T_3 (aquasorb) and T_4 (silt andaquasorb). At the depth of 10cm super absorbent polymer was spread in T_3 (aquasorb) and T_4 (silt andaquasorb), which forms a thin film layer after absorbing water and restricts the percolation of water into the soil and hence making more moisture retention capacity at the depth of 0- 15cm than 15-30cm.
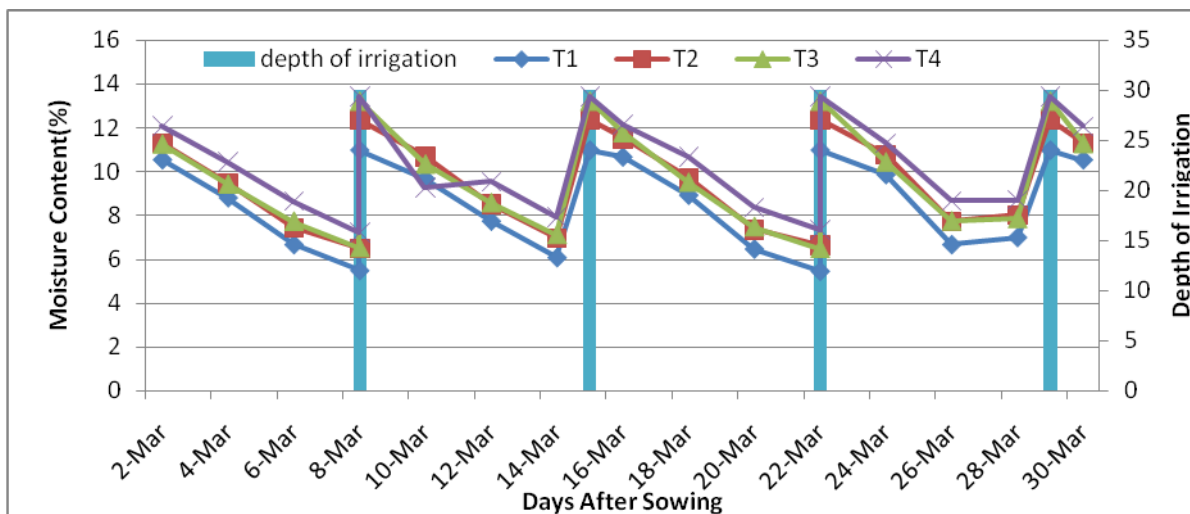

Fig 3. Irrigation Interval of 7 days (at 15-30 cm depth)

Irrigation interval-II (10 days) at the depth of 0-15cm

The moisture depletes 60% of the field capacity on the tenth day after irrigation. The moisture retention capacity decreases significantly with no. of days after irrigation. As mentioned before in case of irrigation interval-I, in this too highest moisture retention capacity was observed under T_4 (Silt and aquasorb application) and the least moisture retention capacity was observed under T_1 (Control). Treatment T_3 (aquasorb application) and T_2 (Silt application) shows highest moisture retention capacity next to T_4 (Silt and aquasorb application).
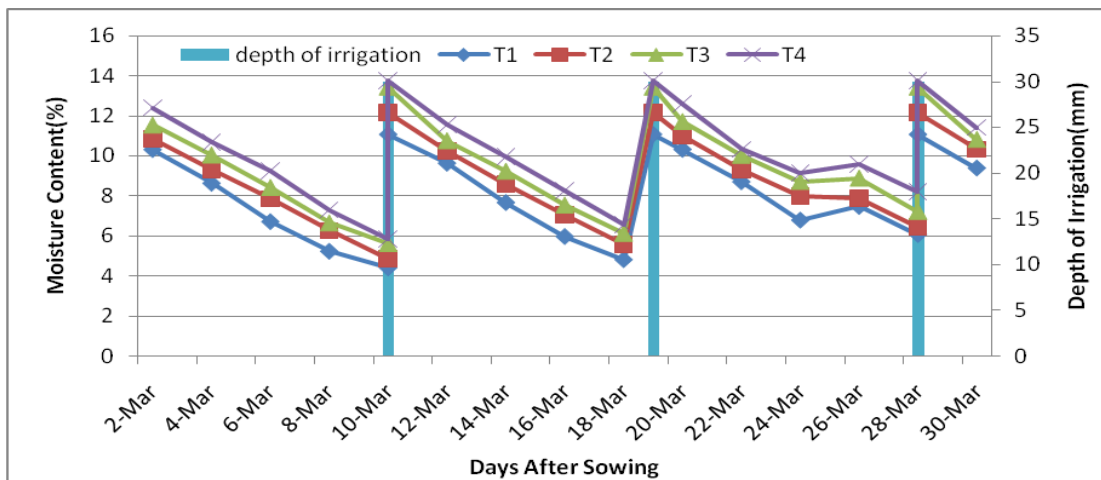
Fig 4. Irrigation interval of 10 days (at 0-15 cm depth)

There was an initial moisture difference between T_4(Silt and aquasorb application) and T_1(control) was 20% and the difference had increased to 30% on tenth day. The observation showed that in 10 days irrigation interval moisture stress was more than the 7 days irrigation interval. In the silt application alone the difference between initial moisture and on tenth day moisture was only 5% while for the aquasorb application the difference was significant around 20% than the control sample.

Irrigation interval-II (10 days) at the depth of 15-30cm

The irrigation moisture depleted with increase in number of days after irrigation. Because of irrigation on particular day moisture content reached to maximum and then depleted slowly till the day of irrigation. And also as compared with moisture content at the depth of 0- 15cm, there was more moisture depletion at the depth of 15-30cm in T_3 (aquasorb application)T_4 (Silt andaquasorb application) because of the application of aquasorb in the soil at the depth of 10cm. While in the T_1(control) and T_3 (silt application) there was less moisture depletion at 15-30cm depth as compared to the 15cm depth. In the silt application about 7% more moisture had retained at the depth of 15-30 cm.

As observed from the fig 5 the moisture of the T_4 (silt and aquasorb application) was 10-15% more than the control and it was maintained upto the tenth days of irrigation. There was a reduction of 2.5% in the moisture content of T_3 (aquasorb application) at the depth of 15-30cm as compared to the 0-15cm depth. Alone silt application had shown the significant difference it had raised from 15% to 30% from first day after irrigation to the tenth day after irrigation.
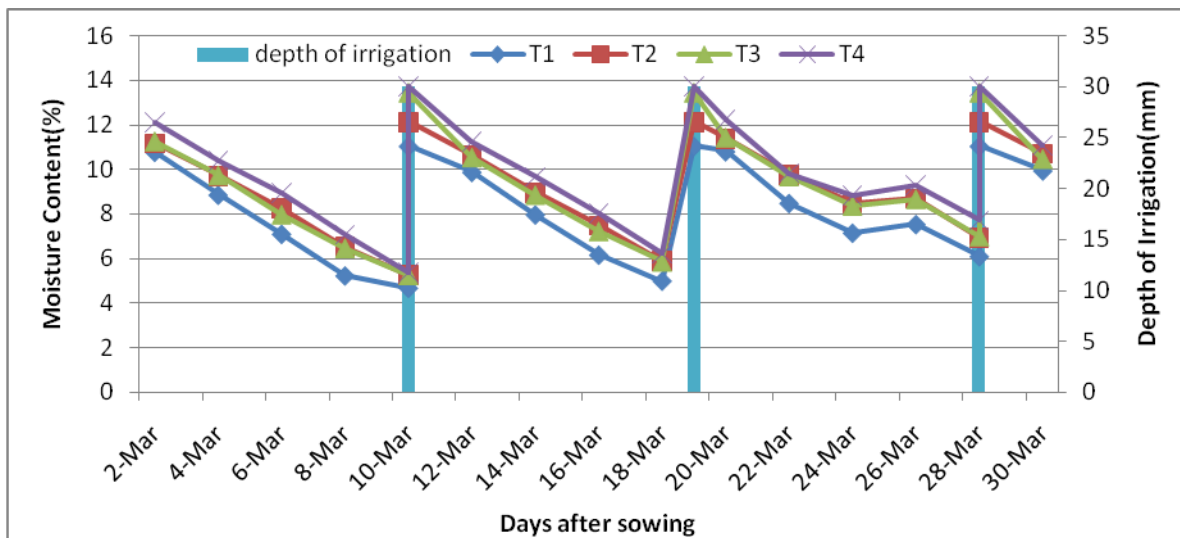

Fig 5. Irrigation interval of 10 days (at 15-30 cm depth)

Effect of ammendments on crop yield

Crop was harvested after 45 days (10/04/2014) from the day of sowing (22/02/2014) and only in the first picking the yield was calculated. Soil amendment like silt and aquasorb were applied for significant rise in yield. Application of silt had shown appreciable increament in the yield whereas there was no observable effect of aquasorb on crop yield. The highest yield was computed in T_4(Silt and aquasorb application)as aquasorb reduces the percolation of water and silt increases the fertility of soil and having high water holding capacity.Irrigation interval has the significant relation with the yield of spinach. Decrease in the irrigation interval results in the incresae of yield and vice versa. So higher yield was observed at 7 days irrigation interval than 10 days irrigation interval.

There was a rise of 35% in the yield for T_4 (Silt and aquasorb application)with respect to the control. Whereas silt effect was also effective and created a difference of 25% and in aquasorb application about 10% increament was observed as compared to the control. While if comparision was made between two irrigation intervals the yield of 7 days interval was appreciable. In case of control irrigation interval of 7 days gave around 15% more crop yield than 10 days interval. Wheras in the rest three treatments there was a minor rise of 7% in the crop yield in the 7 days irrigation interval than 10 days irrigation interval.
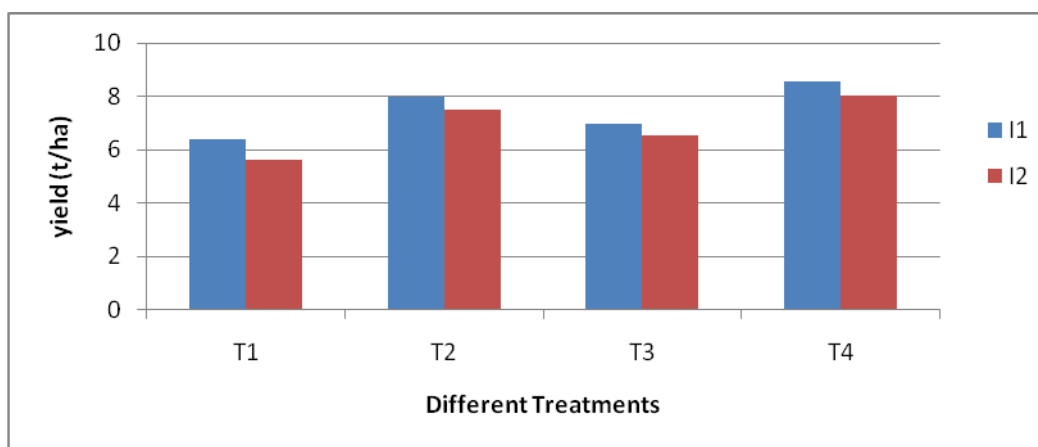

Fig 7. Yield of spinach for different treatments

Assement of water use efficiency for different treatments

Water use efficiency was computed using formula mentioned in 3. In the first irrigation interval i.e. 7 days interval five times irrigation was given @ 30mm of water depth for each irrigation throughout the crop period (150mm of total water depth), whereas in the sceond irrigation interval i.e. 10 days interval it was four times (120mm of total water depth). Water use efficiency was computed higher in 10 days irrigation interval as less amount of water was applied. The highest value was observed in I_2-T_4 (10 days interval and Silt and aquasorb application).
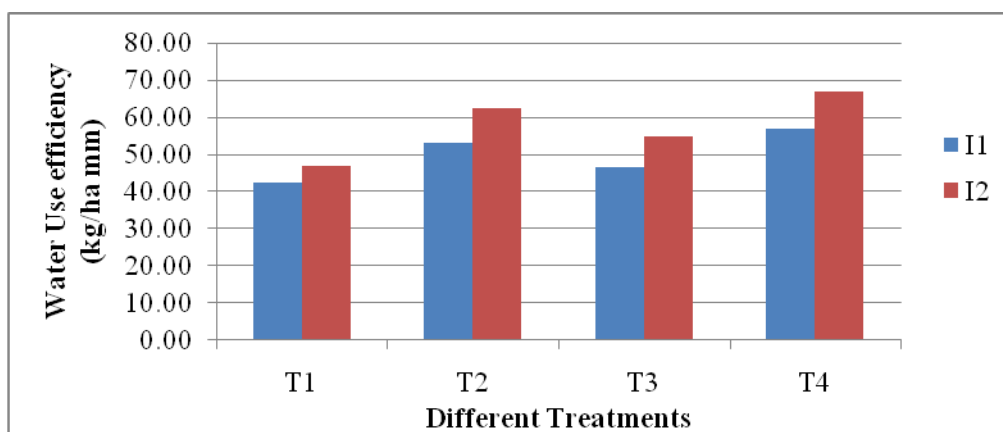

Fig 8. Water use efficiency for different treatments

It was obserevd from the fig 8 that yield had no such effect on the water use efficiency while it was effected by the amount of water given. In 7 days irrigation interval water use efficiency for T_4 (Silt and aquasorb application) was around 35% more than the control. Whereas no much difference was observed in the aquasorb application compared to the control. Silt application showed significantly effect and gave about 25% more water use efficiency than the control.

CONCLUSIONS

The highest crop yield was obtained inSilt and aquasorb application and the lowest yield was found in control. Silt application showed the best result in accordance with crop yield next to Silt and aquasorb application. But, aquasorb did not show the significant yield more than the control. The highest water use efficiency was received in Silt and aquasorb application in 10 days irrigation interval as the respective yield was more. Whereas the lowest water use efficiency was found in T_1 (control) in 7 days irrigation interval as yield was minimum because of poor soil moisture retention characteristics and low fertility. 10 days irrigation efficiency shows the significant higher water use efficiency than 7 days irrigation interval.

REFERENCES

Ahmed A., (1990). Applications of Functionalized polymers in agriculture. Journal of Islam Academic Science, 3(1): 49-61.

Ekebafe, L. O. (2011). Polymer Applications in Agriculture. Nigerian Society for Experimental Biology. 23(2): 81–89.

Gill, H. S. and Abrol, I. P. (1990). Evaluation of coastal sandy soils and their saline ground waters for afforestation. An international journal of new forest. 4(1): 37-53.

Tiwari, R, Parama, R.V.R., Murthy, I. K and Ravindranath, N.H. 2014.Irrigation tank silt application to croplands: Quantifying effect on soil quality and evaluation of nutrient substitution service. International Journal of Agricultural Science Research. 3(1) : 1-10.

Virendranath, G. 2013. *Vyasaya Panchangam*

Yadav, J. S. P., Sen, H. S. and Bandyopadhayay, B. K. (2009). Coastal soils- management for higher agricultural productivity and livelihood security with special reference to India. Journal of soil salinity and water quality. 1(1&2): 1-13.

INTERNATIONAL JOURNAL OF
APPLIED BIOLOGY AND PHARMACEUTICAL TECHNOLOGY