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Research Paper

Influence of surface and sub-surface drip irrigation methods on performance and yields of two tomato varieties

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ABSTRACT

The water conservation is vital to maintaining agricultural production in areas of small rainfall or jagged rain sharing. Under this situation, surface and Sub-surface drip irrigation way of irrigation may play a momentous role in overcoming the paucity of water and economic production of vegetable crops, particularly in water shortage areas. A greenhouse study was designed for varietals organic seed production of two tomatoes crop verities under surface and sub-surface drip irrigation design. The objective of the study was to produce good varietals organic seed production and in addition to know the performance of these two irrigation methods in respect of their water used efficiencies, crop yield, yield to water ratio and economic testing of these two ways of irrigation at Al-Qassim, Saudi Arabia. Better establishment of crop with higher yield and yield to water ratio was obtained in sub-surface drip irrigation method, irrespective of their varieties used under for both drip irrigation methods, it is only due to better water use efficiency of sub-surface drip irrigation method. Sub-surface drip irrigation method also proved a viable choice for vegetable crop production under scarce water situation.

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Key words: Surface and Sub-surface drip irrigation way, tomatoes vegetable, arid region, drip pipe pliability.

Abbreviations: ETo: Reference evapo-transpiration**, LFDP:** Low flexible drip pipe**, IW/PAN-E:** 1.0 Irrigation level**, O.D:** Outer diameter.

INTRODUCTION

The world population growth is likely to be concentrated in the rising and slightest industrial countries. The inhabitants in the rising countries are likely to grow up from 4.3 billion in 2002 to 5.5 billion in 2025 and 6.2 billion in 2050. For the least industrial countries these statistics will be 0.8, 1.1 and 1.6 respectively. Thus, to maintain the present living standards food contribution will have to rise by at least 44% in the promising countries and 100% in the slightest developed countries. This is the estimate for a bare minimum. Actually much more would have to be produced for maintaining a desirable standard of living (Schulz, 2005).

A key restraint to agricultural production is the accessibility of water for crop development. Water is over and over again a foremost restrictive issue in regions of small rainfall (semi-arid and arid regions) or in agro-climatic zones where rain is randomly distributed all over the year (UNEP, 2001).

It is vague that between 2000 to 2025 AD the worldwide each year water accessibility per person will lessen from 6600 to 4800 cum. Due to bumpy allocation of water resources about 3 billion people will live in countries entirely or partially arid or semi arid having fewer than 1700 cum. Countries are assumed mostly as harassed when the yearly per person accessibility is between 1000 to 2000 cum, respectively. It may be noted that more than 1 billion people plus one-third of the inhabitants of China and India living in arid regions would be overlay water security (Thate, 2002).

Slack period vegetables making which includes cucumber, tomato, capsicum and cauliflower required additive water. Adoption of water conservation techniques that leads to minimizing the use of water for irrigating crops is vital for credible economic production of vegetable and other cash-crops in the arid period particularly, November to May or June, as an copious contribute of water is not accessible during the dry period (Randhawa and Abrol, 1990).

A considerable bang of globalization on horticulture has been a growing stipulate for feature expansion and the wider acceptance of eminence values for fruit, vegetable and salad goods. Tomato (Lycopersicon esculentum Mill.) is a main horticultural crop with a sketchy global making of over 120 million metric tons (FAO, 2007).

To this upshot, drip irrigation provides a practical choice for economic production in areas of small rain or periods of water paucity. Drip irrigation refers to any technique of irrigating sown crops in which the water is provided directly to every individual plant on a steady and incessant basis (Swhwab et al., 1993).

Performance of drip and furrow irrigation was studied on tomatoes in sandy loam soil. Two irrigation levels IW/PAN-E 1.0 and 0.7, all parameters of plant height, number of branches, leaf area index and yield were significantly less with furrow than with drip irrigation. There was a decrease in all parameters with decrease in IW/PAN-E both in furrow and drip irrigation. Almost one and a half times higher yield was obtained with drip irrigation than in furrow irrigation along with a 30% saving in water (Kahlon and Mand, 2005).

Micro irrigation of tomato with different crop geometries was studied. The treatment consisted of 5 drip lateral spacing. Pooled results of 3 years showed that significantly higher yields (46.44 tons/ha) was obtained when drip lateral was spaced 1.5 m apart with a plant spacing of 20 cm which was higher by 55% over normal planting (45 cm × 60 cm) with lateral spacing of 1.5 m apart (control) (Rao et al., 2005).

A cram was initiated to discern the effectiveness of surface drip irrigation way of irrigation and sub-surface drip irrigation under vegetable crop like cucumber and tomatoes. The outcomes of the cram reflected surface drip irrigation way gave fine development of crop and good produces than sub-surface drip way. Additional work is required to set up source-result affairs and actual possibility of sub-surface drip irrigation technique (Bajracharya and Sharma, 2005).

A comparative study was carried out under drip and furrow irrigation systems for two seasons to see the response of saline drainage water on tomato crop were guesstimated together with soil wetness and salt allocation. The study results showed that with the rise in salinity leaf area index, plant dry weight, produce and entity fruit weight were reduced. It was also observed that yield, growth parameters and water use efficiency were more in drip than furrow irrigated plants. But, furrow irrigation gave high entity fruit weight and salinity followed the water front. They suggested that vigilant and well-organized supervision of irrigation with saline water could depart groundwater salinity levels unchanged and suggested that under drip irrigation method, produce per unit of water used was on average one third upper than furrow irrigation way of irrigation (Malash et al., 2008).

The purpose of this study was to produce organic seed and to appraise the worth of two way of drip irrigation, explicitly surface and sub-surface drip on the recital and produce two tomato varieties named Notorah and redrock under arid climate of Saudi Arabia.

MATERIALS AND METHODS

Site description

The study area is situated nearby Buraidah city of Al-Qassim province, Saudi Arabia as shown in the Figure 1. The study area lies at altitude 574 to 724 m with latitude and longitude ranges from 26.1 to 30.0°N and 37.0 to 41°E respectively. A small greenhouse comprising 1200 m2 was selected from the existing greenhouses of Agriculture Company, located in the deserts of Al-Qassim (Buraidah), Saudi Arabia. The region land area consists of sandy loams with indication of gravel. The source of irrigation water was a mixture of five tubewell water.

The study area weather is fairly hot and dry. The usual monthly peak temperature varies from 30°C (minimum) to 48°C (maximum). Relative humidity is about 34.6%, wind speed is 175 km/d and yearly ETo is 2489 mm. Figure 2 shows the climatic data.

Experimental design

One greenhouse comprising 1200 m2 was selected for this study. Figure 3 shows the experimental design layout of this study. The numbers of beds were 20 with bed spacing 1.2 m. Each bed has two irrigation drip pipes, that is, two rows of plants per bed. Table 1 shows low flexible drip irrigation pipes (LFDP) were used and physical and hydraulic uniqueness of the pipe. Two varieties of tomatoes, notorah and red rock were selected for F2 organic seed production. The design distribution of these 20 beds are in such a way that out of 20 beds, 10 beds were selected for notorah variety and 10 beds for red rock variety. Out of 20 beds, 10 beds with surface irrigation system while remaining 10 beds with one variety each were selected for sub-surface irrigation system. Same irrigation schedule were adapted to all 20 beds. Organic fertilizer was used during this study. Some healthy plants with good production were selected from each variety. Among selected plants again selected few healthy plants of each variety that is, from notorah and red rock for the development of F_3 organic seed (Figure 3).

At the cove of water deliver line, a main flow control valve, a pressure gauge and filtration unit were built-in. The main line was linked to four sub-main lines which direct

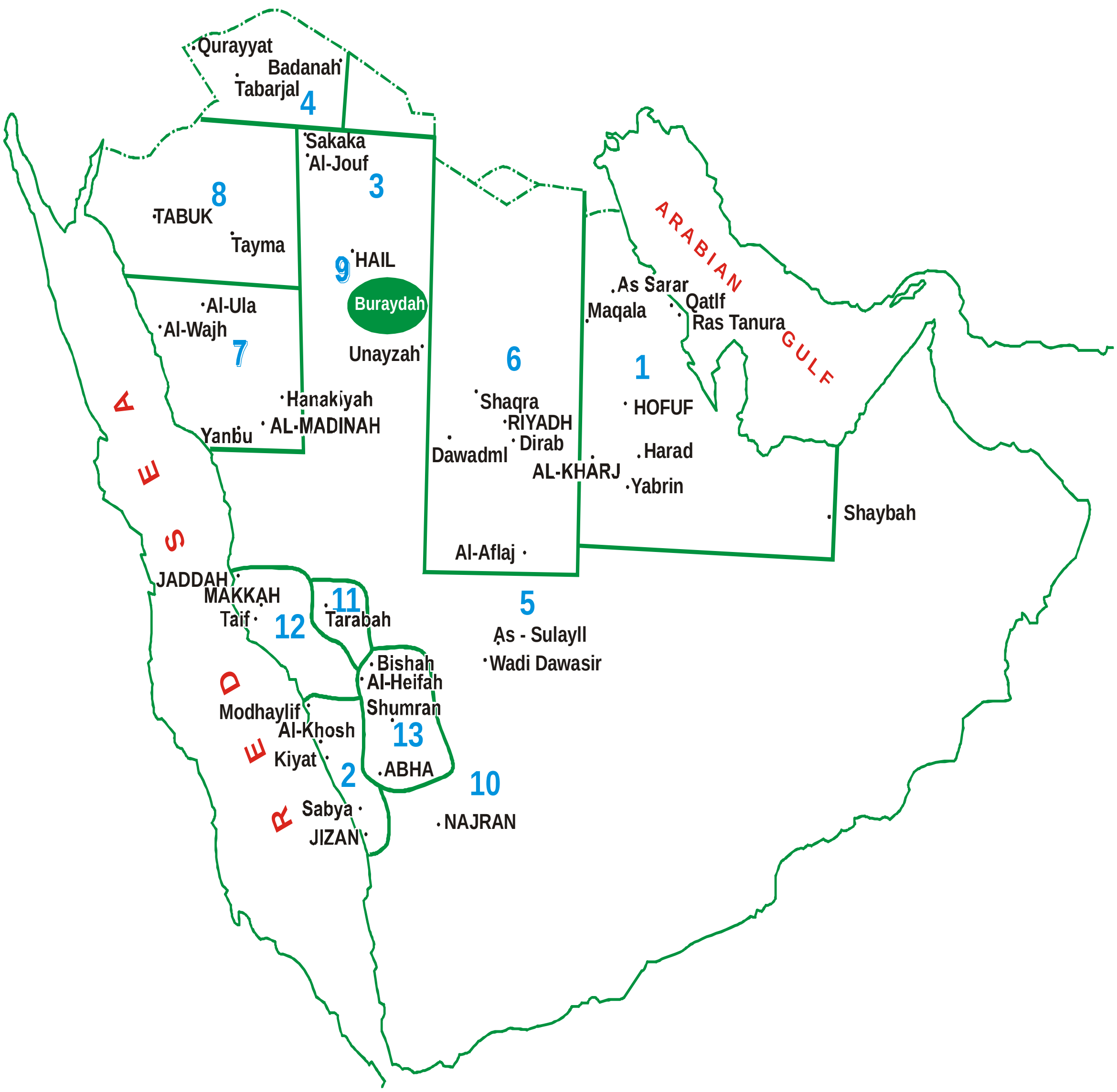

Figure 1: Agro-Climatological areas, Kingdom of Saudi Arabia (Experimental sites Buraydha, Al-Qassim, Saudi Arabia).

water to sub-areas through laterals. These laterals were positioned above ground surface and further attached to drip pipes located above ground surface on the bed for surface drip irrigation block and were buried at recommended depth on bed under sub-surface drip irrigation block. Each block area was fitted with a separate set of control valves. The drip pipes were placed at suggested deepness from ground surface under sub-surface drip irrigation. The scheme was tartan for seepage before starting to back-filling particularly blocks with sub-surface drip irrigation system.

Irrigation scheduling and system operation

Irrigation setting up consists of providing the accurate quantity of water at the exact time. Its reason is to take full advantage of irrigation effectiveness by giving the suitable quantity of water required to top up the soil wetness to the wanted level. Figure 4 shows monthly irrigation schedule was prepared, while Table 2 shows the water analysis of these tubewell was also carried out. The testing was done from May to August. Monthly irrigation timetable was set as per guiding principle recommended by Al-Zeid et al. (1988).

RESULTS AND DISCUSSION

Figure 5 shows that under sub-surface drip irrigation system, high yield were obtained either from notorah verity, 3304 kg, or red rock variety, 2447 kg of tomato crop. Furthermore, regarding yield results for surface drip irrigation, 2379 and

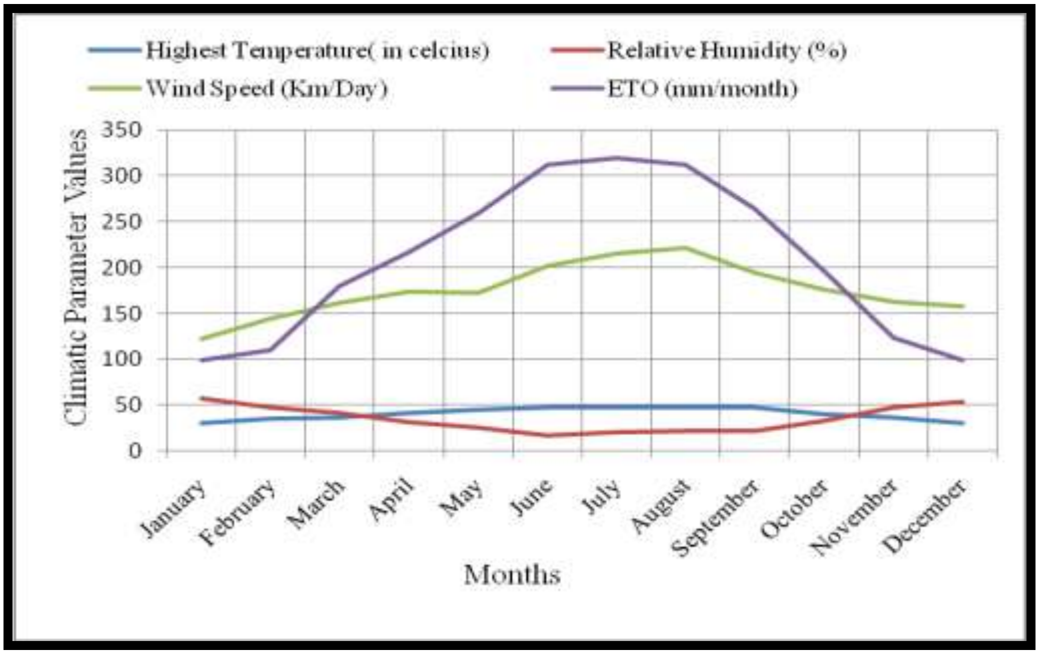

Figure 2: Average monthly climatic data for Al-Qassim, Saudi Arabia.

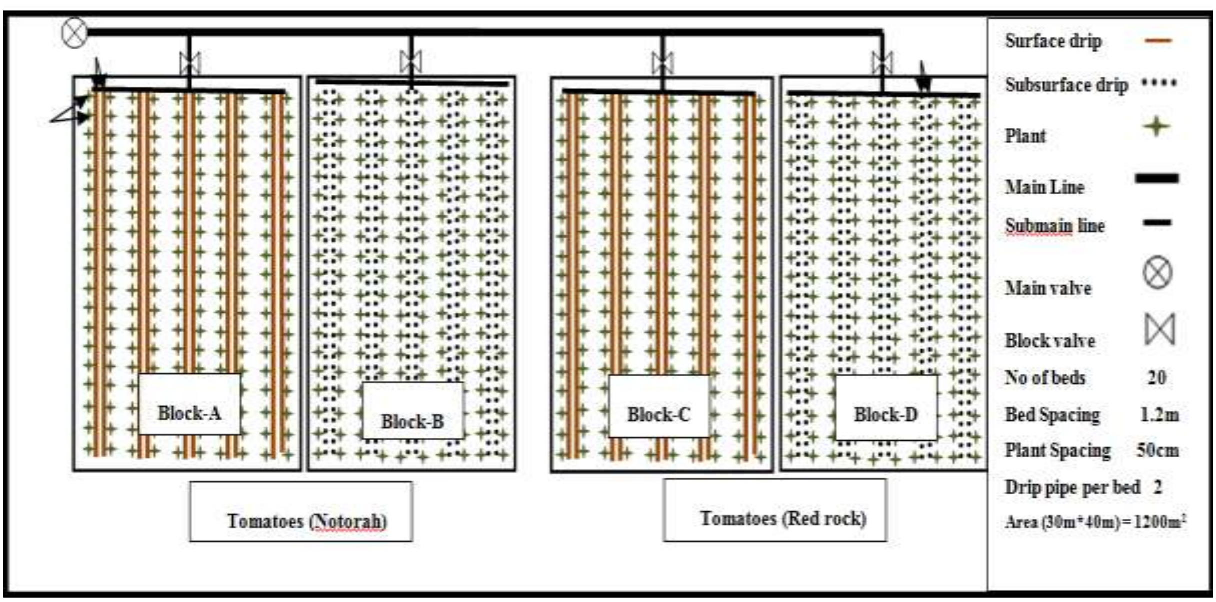

Figure 3: Plan view of experimental site showing irrigation layout and monitoring.

Table 1: Physical and hydraulic characteristics of drip pipe used.

Factor	Pipe type
Type	Low flexible
Diameter (O.D), mm	17
Discharge, L/H	4
Emitter distance (cm)	50
Pressure range (m)	0.5-4
Wall thickness, (mm)	1.0

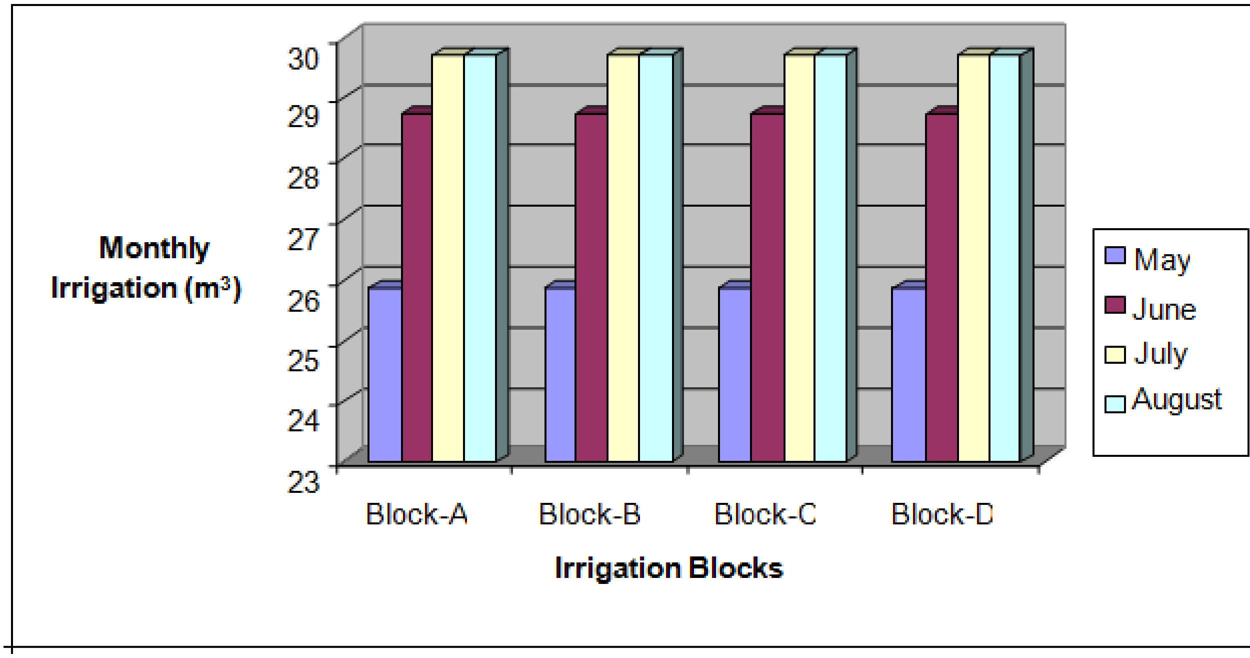

Figure 4: Monthly irrigation applications to Tomato crop under surface and subsurface drip irrigation.

Table 2: Water analyses of experimental site.

Parameter	Experimental Site				
	Well#1	Well#2	Well#3	Well#4	Well#5
pH	7.79	7.86	7.29	7.24	7.63
Total dissolved salts (ppm)	890	1260	570	700	470
Total alkalinity (ppm)	116	140	140	160	146
EC, (ppm)	1784	2490	1158	1405	963
Cl^{-1} (ppm)	302.48	457.7	149.2	195	101.5
Total hardness (ppm)	153.8	152	127	101	79.8
Ca^{2+} (ppm)	50	52	43.6	29	25.6
Mg^{2+} (ppm)	6.54	5.32	4.42	6.96	3.86
Fe^{2+} (ppm)	0.038	0.003	0.009	0.037	0.006
SO_4^{2-} (ppm)	310	496	225	255	190
NO_3 (ppm)	23	47	28	33	27

1835 kg was obtained for notorah and red rock variety of tomato crop that is less in quantity, in contrast with sub-surface drip way of irrigation.

The water use efficiency by means of low flexible pipes has been calculated as 29 kg/m^3, in the case of Notorah, while 22 kg/m^3 under Redrock varities of tomato by using sub-surface drip irrigation method. The yield water ratio under surface drip irrigation was calculated as 21 and 16 kg/m^3, under Notorah and Redrock varieties of tomato respectively, (Figure 6).

It is clear from results that the whole high yield was obtained under sub-surface drip irrigation method, regardless of its variety. It means that yield under sub-surface drip irrigation is 28% more than the yield under surface drip irrigation system in the case of notorah organic seed production while in the case of red rock yield is 25% more under sub-surface drip system than the yield under surface drip irrigation system. The cause for lesser produce in the case of surface irrigation might be due to insufficient water delivery during growth period and comparatively higher evaporative water losses which significantly reduced crop yields.

Quantitative analysis shows that water use efficiency for both tomato varieties under sub-surface drip irrigation method is 28 and 27% more than that of under surface drip irrigation method respectively. As it has been discussed earlier that this might be due to improved water use efficiency and minimized evaporative losses under sub-

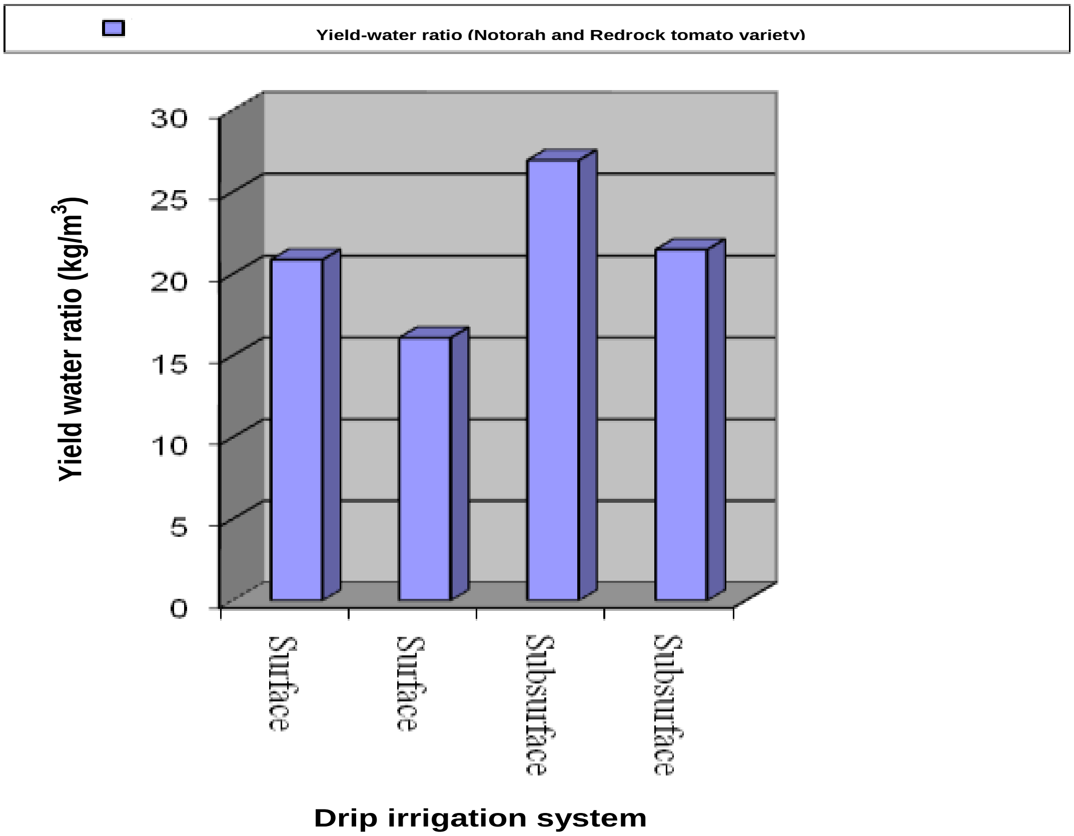

Figure 5: Yields of two tomato varieties under surface and sub-surface drip irrigation system.

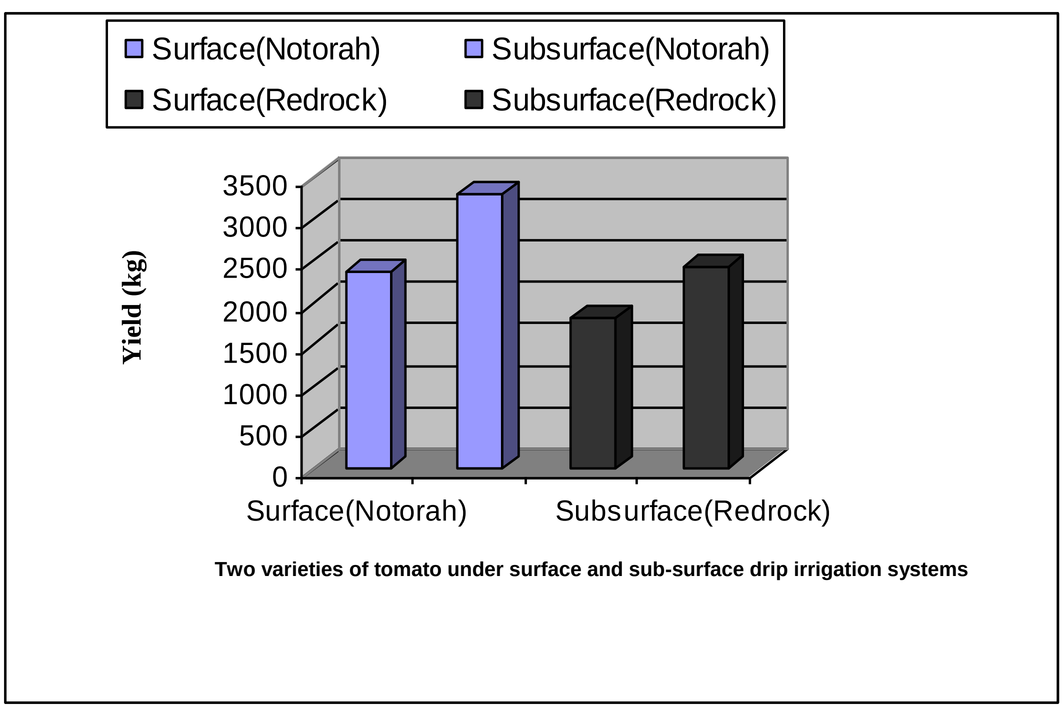

Figure 6: Yield water ratios under surface and sub-surface drip irrigation systems.

surface, as water delivered directly to the rootzone as compared to surface drip irrigation method (Bajracharya and Sharma, 2005). The cost analysis depicted that sub-surface drip irrigation system was more practical economically.

Conclusions

Micro-irrigation system of irrigation for vegetable crop has been widely used for improving water efficiency and yield in most of the world and has attained good results. These result shows that sub-surface drip irrigation technique is more improved than surface drip irrigation way. We found that improved vegetable crop yield with high-quality water use effectiveness in sub-surface drip irrigation scheme due to non-evaporative water losses either temperature or wind.

This cram checked the performance of a surface and sub-surface way of irrigation using pipe of stumpy flexibility. Derived from the investigational outcomes, the following main conclusions of the study under vegetable crop are drawn from this investigation:

- Low flexible drip pipe (LFDP), having continued self-cleaning mechanism performed well in sub-surface drip irrigation system due to their physical and hydraulic features.
- Formation of more wetted volume of soil in the root zone was found, in the case of sub-surface drip way of irrigation and minor wetted volume of soil was observed in surface drip way of irrigation, which means that all volume of water consumed in sub-surface drip irrigation system also saved irrigation water due to non evaporation and wind effects.
- Higher yield and yield to water ratio was obtained in sub-surface drip irrigation method and regardless of their varieties used under both drip irrigation methods, it is only due to better water use efficiency of sub-surface drip irrigation method.
- Sub-surface drip irrigation method proved a viable alternative for vegetable crop production under water restrictive conditions.
- Even though fixed and capital expenses of sub-surface drip way of irrigation was more but profits collected and gross margin in US$/ha/season in sub-surface drip way of irrigation was more as compared with surface drip way of irrigation.

RECOMMENDATIONS

More research of sub-surface drip way of irrigation needs to be done for greenhouses planting of other vegetable crops to validate the characteristics of the employment of low flexible drip pipe kind in this way of irrigation. For proficient scheme functioning, maintenance rota as suggested by the manufacturer must be observed to acquire the best results in these drip ways of irrigation.

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