# SUBSURFACE DRIP IRRIGATION

**H.S.Chauhan[1]**

## ABSTRACT

Subsurface drip method of micro irrigation is different from surface method only in the way that the lateral pipes are buried below the ground surface unlike the same laid on the surface. It is a highly efficient method of water application, with minimum of water losses through evaporation and deep percolation, thus assisting water and nutrient conservation. According to 1991 survey, subsurface drip was reported to be practiced only 3% of the total area covered by micro irrigation. It was practiced in the USA, Israel, China, Canada, and Poland. In the USA, it had an area of 54000, in China an area of 2500 ha, Israel 150 ha and others 2184 ha.

According to Phene (1987) in the areas of water scarcity for salinity management in salt affected area and in permeable soils, subsurface drip irrigation reduces deep percolation losses and long term sustaining ground water contamination. It has all advantages of surface drip irrigation. It increases Water Use Efficiency, and eliminates deep percolation.

This system of micro irrigation has been applied to many crops and fruits, nuts, and vine crops have been increasingly irritated by SDI. Considering the range of applicability, it has been applied to a large range of fruits, vegetables and other field crops.

The objective of the present paper is to review the experience of its application to a few fruits, such as peaches and grapes, vegetables such as tomatoes, brinjals and lettuces as well as other crops, like groundnuts, cotton, and pasture crops. The applicability and performance of SDI has been reviewed and conclusion drawn for the above crops.

## INTRODUCTION

Sub surface drip method is infect an old method, which according to House (1920) used it to apply to apples alfalfa and serials with perforated subsurface pipes. THz method was however quite expensive and not economical for field crops. With introduction of plastics appropriate lateral pipes have now been developed and its feasibility of application has been experimented for several crops.

In the earlier stage of its experimental stage there were problems of root intrusion, plugging of emitter, installation problems and especially very complex management of fertility management; however it has been solved to a good extent by USDA ARS Phoenix Arizona and Fresno California.

---

1- Former Professor Irrigation and Drainage Engineering, Dean College of Technology, Dean Post Graduate studies, G.B.Pant University of Agriculture and Technology, Pantnagar263145, Distt UdhamsinghNagar, Uttarakhand India.

According to 1991 survey of extent of micro irrigation, out of the total area in surface micro irrigation of 1,710,153 ha or 97 percent, subsurface micro irrigation was only 58,834 ha or about 3 percent only. This was reported to be practised only in the USA, Israel, China Canada and Poland. In the USA it had an area of 54000, in China an area of 2500 ha, Israel 150 ha and others 2184 ha.
According to Phone (1987) in the areas of water scarcity and Nitrogen conservation in salinity management in salt affected area and in permeable soils subsurface drip irrigation reduces deep percolation losses .Long term sustaining ground water contamination. It has all advantages of surface drip irrigation. It Increase Water Use Efficiency, and eliminates deep percolation.
This system of micro irrigation has been applied to many crops and Fruits, nuts, and vine crops have been increasingly being irrigated by SDI. Considering the range of applicability, it has been applied to potato, tomato, cantaloupe, strawberry, lettuce cotton, grapes, apples, almond, peach walnut, turf and various ornamental.
The objective of the present papers to review the experience of its application to a few fruits, such as 1)peaches and2) grapes, few vegetables such as1) tomatoes, 2)urinals and 3)lettuces and other crops, like 1)groundnuts ,2)cotton and 3)pasture crops After the review of experience conclusions have been derived

# 1. EXPERIENCE ON FRUITS

**1.0. Peaches**
**The studies 0n 3 fruits are as given below**
**1.1. Surface, subsurface drip, micro jet, Furrow, water economy and yield**

**Bylaw et al 2003** studied in California USA the effects of furrow, micro jet, surface drip, and subsurface drip irrigation on vegetative growth and early production of newly planted 'Crimson Lady' peach (Prunus persica) trees. Furrow treatments were irrigated every 7, 14, or 21 days; micro jet treatments were irrigated every 2-3, 7, or 14 days; and surface and subsurface drip (with one, two, or three buried laterals per row) treatments were irrigated when accumulated crop evapotranspiration reached 2.5 mm. The overall performance showed that trees irrigated by surface and subsurface drip were significantly larger, produced higher yields, and had higher water use efficiency than trees irrigated by micro jets. In fact, more than twice as much water had to be applied to trees with micro jets than to trees with drip systems in order to achieve the same amount of vegetative growth and yield. Yield and water use efficiency were also higher under surface and subsurface drip irrigation than under furrow irrigation, although tree size was similar among the treatments. Little difference was found between trees irrigated by surface and subsurface drip, except that trees irrigated with only one subsurface drip lateral were less vigorous, but not less productive, than trees irrigated by one surface drip lateral, or by two or three subsurface drip laterals. Within furrow and microjet treatments, irrigation frequency had little effect on tree development and performance with the exception that furrows irrigation every 3 weeks produced smaller trees than furrow irrigation every 1 or 2 weeks.

**1.2. Grapes**
**1.2.1. Surface and surface drip yield and fruit quality**

**Mattock 2000** investigated in Gharabia Governorate the response of King Ruby seedless grapes to subsurface drip irrigation system in old valley of Egypt characterized with silt loam soil. Soil water, salinity distribution, weed growth, crop yield (quantity and quality) and water use efficiency by grapes were measured. Better response of King Ruby seedless grapes to subsurface drip irrigation system in silt loam soil in old valley of Egypt. Comparison of the results between subsurface drip irrigation and surface drip irrigation systems showed that the highest yield and the best quality of grapes were obtained under subsurface drip irrigation system.

1.2.2Yeld and quality with surface and subsurface drip

Wonderland Schmuckenschlager (1990) studied Trollinger, a drought sensitive cultivar on Kober 5BB grown at 1x3 meter on a dry slope and given minimum irrigation to sustain the vines during periods of drought (control), in addition to the experimental irrigation. The mean fruit yields from 1984 to 1998 were : 0.120 kg/sqm. In the control, 0.206 kg/sqm, when supplied with 80liters/plant annually by trickle irrigation and 0.274 kg/sqm, when supplied with 40 liters/ plant annually by subsoil irrigation... All yields were unsatisfactory. Must sugar and a acidity were unaffected but cane weight was increased by 22 percent by trickle irrigation and 37 percent by subsoil irrigation.

## 2.0. EXPERIENCE ON VEGETABLES

**Experience On 3 studies on Tomatoes and one study on Brinjals are given below**

### 2.1. Tomatoes

#### 2.1.1. Trickle, subsurface irrigation, yield and fruit size

**Pitts et al (1988) in** a 2- year field trials to compare the micro and subsurface methods of irrigation on tomatoes, only slight differences were found in yield per plant and fruit size...

2.1.2 Sub surface drip, and surface drip

**Davis et al (1986)** Studied trickle frequency and installation depth on processing tomatoes (cvUC-82B) grown in a clay loam soil in California. Three treatments were given viz. high frequency subsurface drip, high frequency surface drip and low frequency surface drip irrigation. It was found that yield, quality and evapotranspiration of tomatoes were not affected by the depth placement (surface versus deep subsurface) of trickle laterals when irrigation volumes and frequency were the same. Yield evapotranspiration of surface trickle irrigated tomatoes given the same volume of water indicated that high frequency application improved yields, reduced ET, and increased water use efficiency. Irrigation cutoff prior to harvest by more than 15 days decreased yield quality and water use efficiency of trickle irrigated tomatoes

2.1.3Subsurface Drip and furrow irrigation ,Yield and growth

**Narda and Lubana (1999)** Studies of growth parameters and yield of tomatoes grown under a subsurface drip irrigation system were conducted at Ludhiana, India, and compared with those in the conventional furrow irrigation and surface drip irrigation systems under three different irrigation scheduling criteria. Results revealed that tomatoes under subsurface drip irrigation system performed best in terms of growth dynamics and yield. However, there were problems with emitters clogging up in sub-surface drip systems late in the season.

2.1.4Drip, free drainage and Trough bench sub irrigation technique for Cherry tomato yield and quality

**Santa Maria et al (2003)** Drip-irrigation was compared with the trough bench technique of growing a cherry tomato crop, in terms of (i) pH and EC of the substrate, (ii) production and quality of the fruits and (iii) WUE in the use of the water. In the latter system, pots of opaque plastic with different characteristics were also used: (I) with six bottom holes for sub irrigation and without risers on the bottom; (ii) with four bottom holes and with 3 mm risers on the bottom; (iii) with a furrow cross on the bottom and with eight holes and 3 mm risers. This last pot was also used for the drip-irrigation. With both the fertigation methods the EC of the substrate showed a similar pattern over time in the lower and middle layers (always below 3 dS m-1), whereas in the upper layer of the substrate it increased during the growing cycle with higher values with sub irrigation compared with drip-irrigation, reaching 7.7 and 3.4 dS m-1, respectively. The pots without risers used for the sub irrigation showed the highest variations and values of EC of the recirculation nutrient solution, and the pots with risers and four holes the lowest. Tomato yield was lower with sub irrigation than with the traditional free drainage drip-irrigation technique, but the quality was higher (dry matter, total soluble solids, and titratable acidity). Furthermore, with sub irrigation the most frequent size class of the fruits was that with a diameter between 25 and 35 mm (considered optimal for cherry tomato), while with the open cycle it was that greater than 35 mm. No significant differences emerged between the three pot types. The water efficiency of the system was greater with sub irrigation than with drip-irrigation. To produce 1 kg of fruits, 41 l of nutrient solution were necessary with the sub irrigation (closed system) and 59 l with the drip-irrigation (open system).

### 2.2. Eggplant/Brinjal

#### 2.2.1. Surface subsurface drip and yield

**Gibbon (1973)** compared drip and trickle subsurface irrigation and surface Irrigation and reported that the area irrigated by drip produced bigger, healthier plants, More fruit and higher fresh and dry weight Urinal, than what surface irrigation in Similar area did. Yields without fertiliser were greater with drip system than with Surface irrigation

## 3.0. EXPERIENCE OF OTHER CROPS

**Experience on Cotton, Tomatoes Groundnut, Lettuce, Pasture and Field crops are given below**

### 3.1. Cotton, Tomatoes and Grapes

<u>Surface, Sprinkler; Less water and more yields</u>

Phone et al 1993 gave 3 examples of successful and advantageous application of SDI as below

They carried out experimental implementation of SDI at Sundane farm at Coolige . They compared the performance of precise land leveling, surface irrigation, sprinkler irrigation and central pivot system on cotton crop

with buried drip tubes they could reduce water application by 50% increase cotton yield from 1400kg/ha for furrow irrigation to 2240 kg with SDI. They concluded if SDI is properly installed and managed it could work satisfactorily from 10 -20 years.

At Simpson vineyard in Fresno California in all 500 acres, having seedless grapes irrigated and fertilized by SDI system.

It was found that the crop productivity doubled and water consumption cut by 50%

At Vaquero farm they installed SDI in1000 ha for growing processing tomatoes. Productivity and after conservation increased directly with increased at Brentwood California

### 3.2. Groundnuts

<u>Irrigation, SDI:High pod yield and kernel size</u>

**Sorensen et al(2001)** studied feasibility of installing SDI on ground nut in Georgia.. Vegetable and row crop has been successful with SDI, but pod yield and kernel size distribution data on groundnut (Arachis hypogaea cv. Georgia Green) are limited during the installation year. Site 1 was established in 1997 on a Frackville sandy loam soil (clayey, kaolinitic, thermic, Typic Paleudults) converted from grass pasture. Site 2 was established in 1998 on a Tifton sandy loam soil (fine-loamy, kaolinitic, thermic Plinthic Kandiudults) following two years of cotton. These SDI systems included two lateral spacing (0.91 and 1.83 m) buried at 0.3 m soil depth. Site 1 had two emitter spacing (46 and 61 cm) and two irrigation levels. Site 2 had one emitter spacing (46 cm) and three irrigation levels. A non-irrigated (NI) control was included at each site. Irrigation water was applied daily based on estimated ETo where irrigation level one (IL1) was ETo*Kc, and IL2 and IL3 were 75 and 50% of IL1, respectively. Pod yield increased 38% with SDI (5433 kg ha-1) compared to NI groundnut (3937 kg ha-1). The percentage of jumbo kernels increased 39% at Site 1 and 81% at Site 2 compared with NI. SDI groundnut had lower quantity (75% less) of number one sized groundnut kernels than NI. Overall, during the installation year, SDI had higher pod yields and larger kernel size than NI treatments. These yield data can be useful for projecting economic feasibility of installing SDI and making the first year payment.

### 3.3. Lettuce

<u>Drip, SDI, bigger heads and larger heads with SDI</u>

Senath and Pierzgalski (19930) studied the performance of drip and subsurface drip on lettuce.

Drip had lateral of 16 mmdiameter and spacing and emitter spaced at 0.5 m with outflow 2.1 l/m

Perforated tube s was buried at 2.45 m depth and spacing of tubes was 1m. Spicing was .5 m with output 0.4l/h

Studies on Lettuce concluded that 27.7% of lettuce with dip irrigation did not attain minimum head mass. In subsurface irrigation only 5.6% were out of selection. Lettuce under drip had poor quality and was small .Subsurface irrigated lettuce yielded bigger lettuce heads and were of higher weight and thus better commercial quality. Lettuce irrigated with drip irrigation accumulated smallest amount of Nitrate. With Subsurface

### 3.4. Pasture Irrigation

<u>Border and Sidles water with SDI</u>

Lucy Finger and wood (1906) presented a field experiment at Tatura, Australia, to evaluate the performance of four irrigation methods for the dairy industry, including subsurface drip. The dairy industry is a major user of irrigation water in Australia and under increasing pressure to improve water use efficiency. Currently 90% of irrigated pasture uses border-check (surface) irrigation. Some farmers are looking to alternative irrigation methods such as subsurface drip irrigation to improve their water use efficiency. Few studies have investigated subsurface drip irrigation of pasture.

Measurements included the volume of water applied, volume of runoff, pasture production, pasture composition and soil moisture status. Subsurface drip used 200 mm/yr less irrigation water than border check and produced 0.9 to 1.0 t DM/ha/yr more pasture. Visual striping of the pasture was apparent during summer. This indicates the subsurface drip system design was not optimal, yet it still produced more pasture than border-check using less irrigation water. Subsurface drip irrigation has great potential for use on Australian dairy farms, but further investigation is required before the industry will be confident it is an economically viable alternative to border-check irrigation.

### 3.5. Field and vegetable crops

Retrievable tape replaces and SDI for field and vegetable crops
Burt (1906) presented an overview of the general shift from SDI to retrievable tape. It also discusses broadly on the experience of users, the tape materials, installation methods, lying and retrieval methods, practices, equipment and performance. The paper also provides some results of coefficient of variation (cv) tests in relation to number of uses of the tape.

Tape retrieval practices have now reached well beyond the theoretical realm. Over the last 10 years, growers of cauliflower, lettuce, celery, and broccoli on the Central Coast of California have generally shifted from SDI to surface retrievable tape. It is expected that drip design and practices will continue to change as new technology and materials are introduced.
In recent years, new equipment and techniques developed by farmers and private industry have improved the suitability of surface drip tape as an alternative to subsurface drip irrigation (SDI) for field crops and vegetable crops in highly mechanized farming. Retrievable drip tape systems now lack many of the disadvantages of SDI, yet provide the advantages typically expected from drip irrigation.

This paper provides an overview of the general shift from SDI to retrievable tape. It also discusses broadly on the experience of users, the tape materials, installation methods, lying and retrieval methods, practices, equipment and performance. The paper also provides some results of coefficient of variation (cv) tests in relation to number of uses of the tape.

## 4.0. CONCLUSIONS FROM REVIEW OF ABOVE EXPERIENCES

**The following conclusions can be drawn from the review**
### 4.1. For Fruits

In case of fruits such as **peaches** Little difference was found between trees irrigated by surface and subsurface drip, except that trees irrigated with only one subsurface drip lateral were less vigorous, but not less productive, than trees irrigated by one surface drip lateral, or by two or three subsurface drip laterals.
**Grapes**
Incase of King Ruby grapes Comparison of the results between subsurface drip irrigation and surface drip irrigation systems showed that the highest yield and the best quality of grapes were obtained under subsurface drip irrigation system.For Trollinger grapes a drought saving variety Comparison by different methods all yields were found to be unsatisfactory. Must sugar and an acidity were unaffected but cane weight was increased by 22 percent by trickle irrigation and 37 percent by subsoil irrigation.

### 4.2. For Vegetables
**Tomatoes**

**In** a 2- year field trials to compare the micro and subsurface methods of irrigation on tomatoes, only slight differences were found in yield per plant and fruit size. (13)

In another study the Yield and evapotranspiration of surface trickle irrigated **tomatoes** given the same volume of water indicated that high frequency application improved yields, reduced ET, and increased water use efficiency. Irrigation cutoff prior to harvest by more than 15 days decreased yield quality and water use efficiency of trickle irrigated tomatoes Yield evapotranspiration of surface trickle irrigated tomatoes given the same volume of water indicated that high frequency application improved yields, reduced ET, and increased water use efficiency. Irrigation cutoff prior to harvest by more than 15 days decreased yield quality and water use efficiency of trickle irrigated tomatoes.

In another study in India Results revealed that **tomatoes** under subsurface drip irrigation system performed best in terms of growth dynamics and yield. However, there were problems with emitters clogging up in sub-surface drip systems late in the season. (.51) in a study of Cherry tomatoes with trough bench technique it was found No significant differences emerged between the three pot types. The water efficiency of the system was greater with sub irrigation than with drip-irrigation. To produce 1 kg of fruits, 41 l of nutrient solution were necessary with the sub irrigation (closed system) and 59 l with the drip-irrigation (open system).

### 4.3. Brinjal

In another study on Brinjals in Tanzania it was found that that the area irrigated by drip produced bigger, healthier plants, more fruit and higher fresh and dry weight Urinal, than what surface irrigation in similar area did. Yields without fertiliser were greater with drip system than with surface irrigation

**Other crops**

In a study of cotton grapes and tomatoes in California it was found At Simpson vineyard in Fresno California in all 500 acres, having **seedless grapes** irrigated and fertilized by SDI system. It was found that the crop productivity doubled and water consumption cut by 50%

At Vaqilro farm they installed SDI in1000 ha for growing **processing tomatoes.** Productivity and after conversion increased directly with increased at Brentwood California

### 4.4. For Groundnuts

The study indicated that Pod yield increased 38% with SDI (5433 kg ha-1) compared to NI groundnut (3937 kg ha-1). The percentage of jumbo kernels increased 39% at Site 1 and 81% at Site 2 compared with NI. SDI groundnut had lower quantity (75% less) of number one sized groundnut kernels than NI. Overall, during the installation year, SDI had higher pod yields and larger kernel size than NI treatments. Pod yield increased 38% with SDI (5433 kg ha-1) compared to NI groundnut (3937 kg ha-1).

**4.5. For Lettuce** the study showed that .Subsurface irrigated lettuce yielded bigger lettuce heads and were of higher weight and thus better commercial quality. Lettuce irrigated with drip irrigation accumulated smallest amount of Nitrate. With Subsurface
**4.6. Study of pasture irrigation** showed that subsurface drip irrigation has great potential for use on Australian dairy farms, but further investigation is required before the industry will be confident it is an economically viable alternative to border-check irrigation. Subsurface drip irrigation has great potential for use on Australian dairy farms, but further

investigation is required before the industry will be confident it is an economically viable alternative to border-check irrigation.

## 5.0. OTHER IMPORTANT ASPECTS

### 5.1. Advantages

It has the following advantages:1)Decrease in labor requirement No yearly installation or removal of mains or and combine and 2)No interference with cultivation or harvesting 3)Larger economic life of the system 4)Reduced evapotranspiration5)Less soil compaction because of less tillage due to fewer weeds5)substantial increaser in water use efficiency WUE 6)Near total elimination of deep percolation and Nitrate higher levy 7)Long terms comparatively.

### 5.2. Physical characteristics of flow

According to physical characteristics as per Phone 1993, the spherical volume of a wetted clay loam soil is 45 percent larger than hemispherical wetted area of di system . Thus the wetted area available for root uptake is 62 percent larger for side than did. The shorter wetted diameter will permit closer spacing than did and thus an improved wetted uniformity

### 5.3. Economics

According to Phone et al (1993a) through the study of commercial cotton grown in several farms SDI returned an average net income 0f $660.0/ha/year, $72.0 and $156 more than the furrow and improved furrow irrigation. Its installation costs ranged between $2000 -$4000 per ha. It was expected to last for about 10 years

In Kansas there was a trend of change over from surface irrigation to Central pivot system. SDI was another possibility. An economic analysis f comparison of central pivot system with SDI application for corn in western Kansas by Dhuyvetter et al (1995) showed that central pivot system was more profitable than SDI . This was because of large difference in initial investment. The study showed that that the relative returns of two systems were highly sensitive to useful life of system initial investment and crop yield

### 5.4. Future scope

SDI is a highly efficient system of irrigation, which appears to be useful for water, and nutrient conservation and improved productivity, long time sustainability of crops, almost eliminating deep percolation and minimizing non point source nitrogen pollution. It however requires precision installation equipment and better technological know-how and skill for installation, fertility management and monitoring. Its earlier rate of adoption compared to surface micro irrigation appears to have better scope for developed countries for applicability to important cash crops

## REFERENCES


1. Burt, C.M (2006)Surface drip tape irrigation systems as an alternative to subsurface drip irrigation(SDI) for field and row crops' 7th Micro Irrigation Congress – ICIDSept. 13-15,
   2006. Kuala Lumpur, Malaysia
2. Bryla, D.R., Trout, T.J., Ayars, J.E., Johnson, R.S. 2003 'Growth and production of young peach trees irrigated by furrow, micro jet, surface drip, or subsurface drip systems'. Horticultural Science 38**(**6):1112-1116.
3. Davis, K.R., Phene, CG. McCormick,R.L.and Hutmacher,R.B.trickle frequency and installation depth effect on tomato. In Proceedings Third international Drip/Irrigation congress Fresno CaliforniaUSANov 18-21 pp896-962
4. Dhuyvetter, Lamm, F.R. and Rogers, D.H. (1995) subsurface drip irrigation (SDI) for field corn an economic analysis In Proceedings Third international Drip/Irrigation congress Fresno CaliforniaUSAIn Proceedings Fifth international Drip/Irrigation congress Fresno Orlando, FloridaUSA pp395-401
5. Gibbon, D. 1973. 'The production of egg plant Solana Melon Gena L. under
6. Surface and subsurface system of irrigation in Tanzania'*, Horticultural. Science.* 48(3)217-221.
7. House, E.B.1920 Irrgation by means of underground porous pipes. Colorado experiment Station Bulletin 14pp
8. Matuk, A.M.,EL Gindy,A.M.,El M.A. Bondok,M.Y.(2000) Grape yield response to subsurface drip irrigation in old valley. Egyptian journal of Agricultural Research 78(3), 1411-1433
9. Ms Lucy Finger[1] and Mr Mark L Wood Subsurface drip irrigation of pasture for
10. Australia's dairy industry 7th Micro Irrigation Congress – ICIDSept. 13-15,
11. 2006. Kuala Lumpur, Malaysia
12. Narda, N.K. and Lubana, p.S.1999Growth Dynamics studies of tomatoes under subsurface drip irrigation; journal of research Punjab Agricultural University 36(3-4 222-233
13. PittsD.J.,Clark,G.A. Albarez,J. EverettP.H. And Grim G.M. 1988 A comparison of micro to subsurface irrigation of tomatoes. Proceedings of Florida state Horticultural Society101- 393-397
14. Phene, C.J., Buck, D.A., Hutmaker, R.B. and Ayars, J.F...Research successes Application and needs of subsurface drip irrigation. Proceedings 15th congress in irrigation and Drainage Hague Netherlands
15. Phene, C.J., Blume M.F., Kille, M.M. S., Meek, D.W. and Re, J.V.(1983). Management of subsurface micro irrigation systems. ASAE PaperNo.83-2598 Amer. Soc. Agri. Engineers
16. Santamaria, P.CampanileG.Parente,AeliaA.(2001) sub irrigation versus Drip irrigation, effects on yield quality of soil less grown Cherry tomato. Journal of Horticultural Science and Biotechnology 200378(3)200-296.
17. Seznach ,J and Pierzgalski E (1993) Nitrogen management in drip and subsurface irrigation
18. Sorensen-RB; Wright-FS; Butts-CL 2001Pod yield and kernel size distribution of peanut produced using subsurface drip irrigation. Applied-Engineering-in-Agriculture. 17 (2):165-169.
19. Wunderer, Wand Schmuck enchlager,J 1990 Mettellungen-klosterneuburg rebe-und-Wein-Obstbau-und Fruchte vevertung results of subsoil and trickle irrigation of vines over several years 49(3) 105-108.