Scope of Subsurface Drip Irrigation in the State of Chhattisgarh

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ABSTRACT

Irrigation is the prime need of the state Chhattisgarh for its agriculture, which support about 80% population. During the last three years, the area under horticulture crops in the state has increased from 95,000 ha to 2.16 lakh ha. Horticultural crops are best suited to micro irrigation system. But, only around three thousands hectare area of the state is under micro irrigation. Therefore, there is great scope of use of micro irrigation in horticultural crops. Among micro irrigation, subsurface drip irrigation (SDI) has been found beneficial in increasing crop yield as well as water saving and use of marginal water as compared to other methods. The SDI system has been used for irrigating more than 30 diverse food and fiber crops including vegetables, horticultural and agronomic crops under different soil and climatic conditions, and utilizing marginal and waste water. With increasing trends in area under horticulture crops and upcoming of special fruit and vegetable markets in the state as well as our experiences signify that SDI has great potential for its use to enhance crop yield and water saving in Chhatisgarh.

Keywords: *Horticulture, Drip irrigation, Subsurface drip irrigation, Crop yield, Water saving*

INTRODUCTION

Rice is one of major crops grown in Chhattisgarh. The central plains of the State are known as the “Rice Bowl” of Central India. Other major crops are coarse grains, wheat, maize, groundnut, pulses and oilseeds. The region is also suitable for growing mango, banana, guava & other fruits and a variety of vegetables. It has abundant minor forest produce like tendu leaves, sal seed, etc. Medicinal plants, bamboo, lac and honey are other cash earners. Chhattisgarh has planned to increase double-cropped areas, diversify the cropping pattern and improve incomes from agro-based small-scale enterprises. The main sources of water in the state are rivers, tanks and ground water. The state has important rivers such as Mahanadi, Sheonath, Indravati, Arpa, Hasdeo, Kelo, Son, Rehar, Kanhar etc that provide lifeline to socio-economic development of the state. Average rainfall in the state is around 1400 mm with erratic temporal and spatial distribution and about 90% of this is confined in the monsoon season during June to September. Due to this variation in the rainfall, agriculture production of the state is affected. Evidently, irrigation is the prime need of the state for its overall development and therefore the state government has given top priority to development of irrigation potential.

Irrigation

To reduce the dependence on rainfall, government is working towards increasing irrigation potential of the state. It is estimated that approximately 4.3 mha can be potentially irrigated covering 75% of entire cropped area in the state. With gross and net sown areas of 5.788 and 4.828 mha, respectively, the irrigation potential created in 2000 and 2006 were 23% and 28.7% of gross sown area (Table 1).

Water is available in State as surface water and ground water. Out of 41.72 billion m^3 usable surface water through rivers from estimated 59.90 billion m^3, present utilization is 9.2 billion m^3. Present utilization of ground water is 2.79 billion m^3 from both estimated and usable 13.68 billion m^3. Most of the land in the state is hard rock with low recharge

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Table1: Source of irrigation and irrigated area (Dept. of Agriculture, Chhattisgarh).

Sl. No.	Districts of state	Source of irrigation									
		Canal		Bore well		Well		Tank		Other	Total
		No.	Area	No.	Area	No.	Area	No.	Area	Area	Area
1	Raipur	103	188630	8134	26944	28307	6048	7894	13198	13995	248815
2	Mahasamund	59	33887	2249	10423	14526	1729	3805	7891	5056	58986
3	Dhamtari	10	81556	8310	17465	6013	2500	20	541	1786	103848
4	Durg	294	101097	17964	70337	7102	5110	622	5622	19647	201813
5	Rajnandgaon	213	51388	1858	5855	10379	4842	454	1864	5171	69120
6	Kabirdham	0	20098	3000	10260	1892	935	45	1912	2563	35768
7	Bilaspur	108	104447	5566	18260	6635	6032	6402	4082	3257	136078
8	Janjgir	8	114674	2918	13277	7294	6541	7638	5245	2590	142327
9	Korba	29	4340	101	78	1558	925	1889	337	1111	6791
10	Raigarh	41	18412	6227	17490	3788	990	2191	5600	6075	48567
11	Jashpur	50	5018	0	0	11435	2066	121	102	1036	8222
12	Sarguja	152	8113	794	255	50656	6191	2472	1795	17838	34192
13	Koriya	77	4912	88	5	8970	896	771	159	1434	7406
14	Jagadalpur	12	187	312	350	4079	984	125	1146	2950	5617
15	D.B. Dantewara	7	900	33	111	654	165	285	3608	744	5528
16	U.B. Kanker	13	5736	1826	5402	4717	1091	631	3606	1896	17731
	Total	1176	743395	59380	196512	168005	47045	35365	56708	87149	1130809

potential. The existing level of groundwater development is low in most parts of the State. This is more so in dry, hard rock areas low rainfall and aquifer recharge. Both, in situ soil moisture conservation and gravity guided micro irrigation are fundamental and reliable in protecting at least one crop. Agriculture productivity is low and variable. The causes of low productivity are soil moisture stress, due to low and variable rainfall or high run-off, inadequate infrastructure and lack of protective irrigation.

Prospect for Horticulture

Mostly paddy is cultivated during kharif season in Chhattisgarh. Gram, mustard, linseed, lathy are grown as second crop after paddy. These crops provide less profit as compared to horticulture crops i.e. vegetables, flowers, medicinal and aromatic plants. Rain fed cultivation and low productivity of rice (about 1.5 t/ha) and recurring drought condition lead to migration of laborers and also marginal farmers. Such a trend can be upturned and socio-economic conditions of the farmers as well as nutritional levels of population can be improved only with proper development of horticulture. About 20% of cultivated area has red-laterite soil, which is mostly unutilized for growing crops. These soils can be better utilized to grow fruit crops.

Horticulture development can assure year-round employment to farm labors and allied sectors like processing, packaging and export can also gain momentum. Special fruit and vegetable markets are also being developed. During the last six years, the area under horticulture crops has increased to 3 lakh hectares. The increase in vegetable area in the State during 2001-05 has has been observed an exponential growth (Fig. 1).

Important horticultural and other crops of the Stats are mango, guava, orange, pomegranate, grapes, banana, papaya, sugarcane, cotton, groundnut, sunflower, flowers, and vegetable crops including

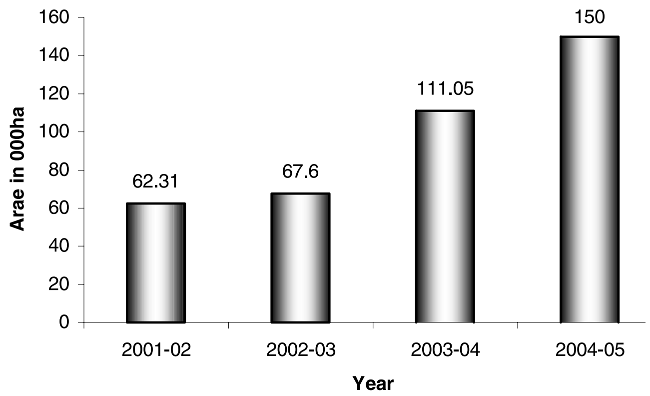

Fig. 1: Growth in vegetable area in Chhattisgarh.

potato, tomato, brinjals, onion, okra and other vegetables. These crops are best suited to micro irrigation system. Presently, only around 47 thousands hectare area of the state is under pressurised irrigation system with three thousnad hectares under drip irrigtaion. Therefore, there is scope of adoption of this irrigation system in these horticultural crops in the State.

Pressurized irrigation

Pressurized irrigation systems are among most efficient irrigation techniques. In India, more than two million-hectare land under vegetables and high value crops is being irrigated through pressurized irrigation system with efficiencies of 60-95%. Pressurized irrigation includes sprinkler and micro irrigation consisting of drip and micro sprinklers with their own advantages and suitability for particular conditions of crop, soil and climate.

The micro irrigation may allow more crops per unit water, and allow crop cultivation in an area where available water is insufficient to irrigate through surface irrigation methods. Moisture availability to crop under drip irrigation methods remains maximum as compared to other irrigation methods. It may achieve field level application efficiency upto 80-90%, as surface runoff and deep percolation losses are minimized (Heerman *et al.*, 1990 and Postel, 2000). The coverage area under theses methods is growing fast in our country. The government of India has proposed to bring a total of 5 mha under sprinkler irrigation by 2012, with ultimate potential about 42.5 mha.

Micro irrigation system

Micro irrigation system (MIS) refers to low-pressure irrigation system that spray, mist, sprinkle or drip. It is the precise, slow and frequent application of water to the plants in the form of discrete drops, continuous drops or tiny streams, through the devices called the drippers or emitters or applicators located at selected points along water delivery lines called as laterals. It provides irrigation with high frequency application of water in and around the root zone of plants.

MIS consists of a pump, main pipe line, sub main pipe, laterals with in line or online emitters or micro sprinklers, pressure gauges, water meter, control valves, filtration unit, fertigation unit, flush valve, air/ vacuum release valves, flush line, ant other accessories required for connections and installation. The laterals are a small plastic tubes combined with emitters or micro sprinklers. The laterals are designed for distributing water into the field. The submain acts as a control system, which can adjust water pressure in order to deliver the required amount of flow into each lateral. It also controls irrigation time for individual fields. The main line serves as a conveyance system for delivering the total amount of water for the drip irrigation system. The system applies water through various emitting devices at low rate under pressure to keep the soil moisture within the desired range for plant growth.

Emitting devices are to dissipate pressure and discharge water in micro irrigation system. These allow a small, uniform flow of water at a constant rate. Drip irrigation uses drippers as water emitting device. These are drippers, micro sprinkler, sprayers and mist according to requirement of crops. The water is also applied below the soil surface if emitting devices are buried in soil, called subsurface drip. Use of micro sprinklers is also getting popularity. However, drip irrigation; lateral placed at soil surface consists of the maximum area under micro irrigation. Use of drip irrigation is growing fast in India. About 1.3 million-hectare areas under vegetables and high value crops were being irrigated through drip irrigation in India during 2008 (Table 2). The net potential area for drip irrigation is estimated to be 21.3 Mha for the country (Narayanamoorthy, 2004).

The Government has planned to bring 14 Mha area under micro irrigation during XI Plan.

Table2: Area under pressurized Irrigation in different states of India.

State	Area under pressurized irrigation, ha		
	Drip	Sprinkler	Total
Rajasthan	15248	684748	699996
Maharashtra	462240	207205	669445
Haryana	6243	512657	518900
Andhra Pradesh	317935	182260	500195
Karnataka	169795	216978	386773
Gujarat	158727	128942	287669
Tamil Nadu	124951	26739	151689
West Bengal	123	150020	150143
Madhya Pradesh	12518	104049	116567
Chattishgarh	2627	44763	47391
Orissa	3361	23187	26548
Uttar Pradesh	10577	10555	21132
Punjab	10427	10276	20702
Kerala	14119	2516	16635
Sikkim	80	10030	10110
Nagaland	0	3962	3962
Goa	762	332	1094
Himachal Pradesh	116	581	696
Arunachal Pradesh	613	0	613
Jharkhand	133	365	498
Bihar	107	180	287
Grand Total	1310956	2320586	3631542

(Source: NCPAH, New Delhi)

Micro irrigation offers advantages of low water delivery rate, low water pressure, precise placement of water; minimum application, field runoff and deep percolation losses. It also improves irrigation control with smaller frequent application, supplies nutrients to the crop as needed, results in less weed growth and improved crop yields (Table 3). The drip irrigation can be made more applicable for irrigating a wide range of agronomic, horticultural and fruit crops by installing the laterals below the soil surface.

Subsurface Drip Irrigation

The drip irrigation system with lateral lines laid on the soil surface is the most popular application method in our country. It has advantage of ease of installing, inspecting and changing emitters, and possibility of checking soil surface wetting pattern and measuring individual emitter discharge rates. The drip irrigation can be made more applicable for a wide range of agronomic, horticultural and fruit crops by subsurface placement of laterals called subsurface drip irrigation (SDI) system. It is defined as application of water below the soil surface through the emitters, with discharge rates generally in the same range as surface drip irrigation (ASAE Std. 1999). SDI specify lateral placement below normal tillage depth or at a depth that would ensure lateral survival throughout the growing season. The main components consists of a pump, main pipe line, sub main pipe, laterals with in –built clog resistant emitters, pressure gauges, water meter, control valves, filtration unit, fertigation unit, flush valve, air/vacuum release valves, flush line, ant

Table 3: Advantage of micro irrigation over conventional irrigation.

Crop	Yield, t/ha		% Yield increase	% Water saving	Increase in water use efficiency, %
	Conventional	Drip			
Banana	57.5	87.5	52	45	176
Chilly	4.2	6.1	44	63	219
Grapes	26.4	32.5	23	48	136
Sweet Lime	100	150	50	61	289
Pomegranate	55	109	98	45	167
Tomato	32	48	50	31	119
Water Melon	24	45	88	36	195
Sugarcane	128	170	33	56	204

(Source: INCID, 1994)

other accessories required for connections and installation.

SDI offers many advantages over surface drip irrigation such as; reduced evaporation loss and precise placement and management of water, nutrient and pesticides leading to more efficient water use, greater water application uniformity, enhanced plant growth, crop yield and quality. The other advantages include less interference with cultural operations and improved cultural practices; allows field operations even during irrigation; less nutrient & chemical leaching and deep percolation; reduced weed germination and their growth; reduced pest and diseases damage due to drier and less humid crop canopies; warmer soils; reduced exposure of irrigation equipment to damage; no soil crusting due to irrigation; and well suited to widely spaced crops. It has advantages of freedom from the necessity of anchoring of the laterals at the beginning and removing it at the end of the season, and thus longer economic life.

SDI system, in beginning was used in California, Hawaii and Texas for the irrigation of sugarcane, cotton, citrus, pineapple, vegetables, avocado, fruits, turf-grass, sweet corn and potato. Multiple vegetables and fruit crops each season have been produced successfully using same SDI system (Camp *et al.,* 1993 and Camp *et al*., 1997). Among vegetable crops grown under SDI system, tomato was the most popular one followed by lettuce, peas, sweet corn, melons, potato, cabbage, beans, squash, carrot, onion, broccoli, asparagus and others. Around 40% of world vegetable crops are grown under SDI system (Toderich, *et al.,* 2004).

The depth of placement of laterals of SDI systems should be sufficient to avoid damage from tillage equipment but shallow enough to wet the root zone. In general the depths of placement of laterals range from 2 to 70 cm. However, for multiple year use of SDI systems, the depths ranged from 20 to 70 cm and lateral spacing ranged from 0.25 to 5.0 m. Though more specific information will be required to determine lateral depths and spacing for specific soil and crop combinations. Laterals in SDI systems are installed at a shallower depths on coarse textured soil and slightly deeper on fine textured soil. Emitter spacing should be such that they provide overlapping wetted areas along the laterals for most of the row crops. On the basis of depth of placement of laterals these are categorized, as Shallow injection, 5-10 cm deep, regular injection, 25 cm deep and deep injection upto 30-45 cm deep (Table 4).

Table 4: Application depth of SDI for different crops.

Shallow injection	Regular injection	Deep injection
Carrot	Sugar cane	Cotton
Onion	Pineapple	Corn
Potato	Eggplants	Sunflower
Yams	Pepper	Beet root
Spinach	Paprika	Alfalfa
Strawberry	Cauliflower	Melons
Garlic	Cucumber	Water melon
Peanut	Celery	Asparagus
Lettuce	Okra	Coriander
Industrial tomato	Sugar beet	Tobacco
Various vegetable	Beans	Soya

Careful management of SDI system on a silt loam soil reduced the net irrigation needs by 25% and gave top yields of corn with reduced Irrigation water use for corn by 35-55% under SDI system as compared with more traditional form of irrigation (Lamm and Trooien, 2003). It was found that emitters installed at a depth of 30 cm induced favorable soil moisture conditions in the active crop root zone. While conventional surface drip facilitated optimal moisture conditions in the upper soil layers. The yield with saline water and emitters at a depth of 30 cm was higher than for on surface drip irrigation (Oron *et al*., 1999).

Fifteen years research work on SDI at Water Management Research Laboratory, USDA- ARS, Fresno, USA, on tomato, cantaloupe, sweet corn, and melon was reviewed and found that uniformity of water application of SDI after 9 years of operation was as good as at the time of installation (Ayars *et al*., 1999). Use of SDI for corn production in Kansas, USA lasted more than 20 years without replacement or major degradation (Lamm and Trooien, 2003).

Increase in yield of tomato was found 12.9 to 22.62

t/ha for SDI system buried at a depth of 20 cm in clay loam soil as compared to sprinkler systems with similar amount of applied water (Hanson and May, 2004). In most of the research work, crops responded positively to SDI system under different depth of placements of laterals. It has been compared to other methods of irrigation; and it was found that crop yields increased considerably due to SDI (Oron *et al*., 1999).

Studies conducted in India indicated that SDI were beneficial in increasing crop yield and saving of water as well as use of sewage water (Singh, 2004; and Luthra and Pandey, 2007,). Study conducted for irrigating okra in sandy loam soils with SDI placed at 0.10-0.15 m below soil surface significantly increased yield. It was recommended that lateral could be placed below 0.10 m of soil surface for enhanced okra yield (Singh *et al*, 2006). In case of onion also lateral placement at 0.10 m was found beneficial in increasing the yields (Patel and Rajput, 2007).

The performance of SDI system was found good after two-years of use in Okra and Onion (Singh and Rajput, 2007; and Patel and Rajput, 2007). Yield of tomato under SDI was found higher than micro sprinkler and, surface drip in black vertisols at Bhopal (Singh, et.al., 2009). Thus, it may be signified that SDI has great potential to enhance crop yield, water saving as well as utilization of marginal water for irrigation in the state.

CONCLUSIONS

The SDI system has been used for irrigating more than 30 diverse food and fiber crops including vegetables, horticultural and agronomic crops under different soil and climatic conditions, and utilizing marginal and waste water. Tomato, lettuce, peas, sweet corn, melons, potato, cabbage, beans, squash, carrot, onion, broccoli, and asparagus are popularly grown under SDI system. The important horticultural crops of the State of Chhattisgarh viz., mango, guava, orange, pomegranate, grapes, banana, papaya, sugarcane, cotton, groundnut, sunflower, flowers, and vegetable crops including potato, tomato, brinjals, onion, okra and others are best suited to micro irrigation system. With the large gap in increasing trends in area under horticulture crops in the state, and present utilization of micro irrigation; and wider applicability of SDI in above crops as well as our experiences signify that SDI has great potential and scope of adoption to enhance horticultural crop yield, and water saving in the State of Chhattisgarh.

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