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Impact of Micro Irrigation Methods on Mulberry (*Morus alba* L.) Leaf Quality and Production

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ABSTRACT

A field experiment was carried out at Regional Sericultural Research Station, a CSRTI Unit, Central Silk Board, Kodathi, Bangalore during 206-17 to evaluate the impact of various micro irrigation technologies and their superiority over traditional flood irrigation was attempted in an established 6 years old tree mulberry planted in wider spacing (8'x5'). A total of 5 mulberry crops were harvested imparting traditional Flood Irrigation (T1) comparing with Surface (T2) and Sub-surface irrigation technologies laying the inline drip laterals at Half feet (T3), One feet (T4) and 1½ feet depths (T5). Pooled data of 5 crops revealed that sub-surface drip irrigation laid at 1½ feet depth (T5) yielded increased a leaf yield of 10,057.08kg/ha/crop followed by T4 (sub-surface at 1 ft. depth) with 9865.88kg, T3 (sub-surface at ½ ft. depth) with 9638.06kg/ha/yr compared to the flood irrigation (T1-traditional method) with 9565.05kg/ha/yr. However, the yield level was not significantly differed compared to the recommended dose of NPK @350:140:140kg and 20MT FYM/ha/yr (10,666kg/ha/crop). However, T2 with surface irrigation yielded lower leaf yield (9467.17kg/ha/crop) compared to all the other treatments. Similar trend was noticed in case of other plant growth, yield and leaf quality analysis. An improved trend of soil physical characters was also witnessed. From the results it is evident that sub-surface drip irrigation methods have shown an edge over the flood and surface irrigation by not only improving the mulberry growth and yield but also economizing irrigation water, frequency of irrigation, improving soil WHC, Bulk density and infiltration of water to the deeper layers of root zones making availability and appropriate utilization of irrigation water.

Key words: *Mulberry, Leaf yield, Rhizosphere, Bulk density, Drip-irrigation.*

INTRODUCTION

Nutrients are taken up by the plants in solution form for which soil moisture without nutrients is of no use to the plants. The sustainability of any production system requires optimum utilization of resources be it water, fertilizer or soil. Irrigation is the artificial application of water which aims to maintain the soil moisture required for an optimum in plant growth.

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Water demand has significantly increased over the last decades while available water resources are becoming increasingly scarce. This is mainly due to the combined effect of climate change, persistent drought and the increase of water demands related to increase in irrigated surfaces. In this context, improvement of water management in agriculture, which is the biggest water consumer, is necessary to enhance agricultural productivity in order to meet food demands of the growing population[10]. The gap between water demand and supply is increasing year after year and declining in availability causing a major threat to agriculture globally. In water scarce area, judicious use of water is essential to get good crop production with limited water supply and adoption of moisture conservation measures[11].

Earlier practices of irrigation were surface and channel irrigation. These irrigation methods involve wastage of water, incurs manpower input on irrigation and making bunds and channels leading to increasing cost of cultivation. Modern drip irrigation has arguably become the world's most valued innovation in agriculture since the invention of the impact of the sprinkler, which replaced flood irrigation. This is because high water application efficiencies are often possible with drip irrigation, since there is reduced surface evaporation, less surface runoff as well as minimal deep percolation[21]. Advantages of surface and sub-surface drip irrigation (SDI) methods in various agricultural crops were established[1,16,17]. Singh and Rajput[20] found that SDI required less water than surface drip irrigation and is different from conventional surface drip irrigation. Small quantity of available water may be applied to a large area plant wise through drip irrigation systems reducing water losses of about 70-80%[14]. Fertilizer and nutrient loss is minimized and moisture within the root zone can be maintained at field capacity followed by minimized weed growth. Fertigation can easily be included with minimal waste of fertilizers.

Flood irrigation as well as drip irrigation technologies too either directly or indirectly dependents on the availability of ground water. As described above due to insufficient and untimely rain fall minimizes recharging of ground water table causing acute shortage for drip as well as irrigation. This situation is compelling sericultural farming community to shrink the mulberry acreage, withdrawing silkworm rearing crops during dry spell, uprooting the mulberry in desperation or compelling the sericulturists to switchover to other crop sacrificing mulberry sericulture. Under the situation alternate methods of economic usage of available water resource for continuing the sericulture has become imperative. Affordable Micro Irrigation Technologies (AMITs) in different farms have come into practice and the State Government of Karnataka also supporting the farming community by supplying the drip irrigation accessories in subsidized schemes[12].

Mulberry (*Morus alba* L.) leaf production and productivity is related to soil moisture and nutrients available therein and both these factors are interrelated and are complementary to each other. It is observed that irrigation increased leaf yield of mulberry plants by about 68%. Hence, increase in leaf production and productivity of mulberry is possible by improved methods of irrigation. However, when mulberry requires 1.5 to 2.5 lit of water per irrigation with the existing quantity of bore well water providing the saturated irrigation by the traditional surface (flood) irrigation for 5445 plants/acre becoming an impossible task. Insufficient irrigation leading to failing to harvest required quantity of quality leaf during drought stricken conditions and incurring of silkworm rearing crop losses. Under the circumstances farmers are adopting tree mulberry in varied spacing such as 5'x5'; 6'x6'; 8'x3'; 8'x5' & 10'x10' for self sustenance, limited water use through drips, convenient for mechanization, averting drudgery of manpower, minimizing wastage by providing plant wise manure, fertilizers and water using varied drip irrigation methods and succeeding in production of enhanced uniform quality leaf and cocoon production[12].

However, in spite of having many economic and other advantages over the method of flood irrigation, the coverage of area under micro-irrigation is not appreciable in India. Among the various reasons for the slow progress of adoption of this new technology, its capital-intensive nature seems to be one of the main deterrent factors. Therefore, through this study an effort was made to demonstrate the advantages involved in micro irrigation technologies in mulberry.

MATERIAL AND METHODS

A pilot study was undertaken during 2016-17 at Regional Sericultural Research Station, Kodathi, Bangalore, Karnataka to evaluate various micro-irrigation technologies comparing with the traditional flood irrigation and their impact on mulberry crop production. The experiment was laid out in a 6 years old established V1 tree mulberry garden planted in wider spacing 8'x5'. The experimental plot soil being sandy loamy in nature initial nutrient status was recorded as neutral soil reaction (pH-6.95), ideal salinity (EC-0.154 dS/m^2), low level of organic carbon (OC-0.43%), low in available nitrogen (N-175.6kg/ha), desired level of available phosphorous (P-24.10kg/ha) and medium level of available potassium (K-161.30kg/ha), respectively. The experiment was designed in randomized block design (RBD) consists with 5 treatments in 5 replications. Each replicated gross plot measuring with 1600sq.ft accommodating 60 plants where as net plot in 1200sq.ft with 24 observatory plants. All the plots were maintained following the standard recommended package of practices[4]. The treatments include *viz.* T1 with Flood irrigation (the traditional method of channel irrigation as control), T2- Surface drip irrigation where the button dripper (with 4 lit/hour water releasing capacity) fitted to 12mm laterals placed on the surface of the soil and near to every tree mulberry plant base. The rest of the treatments such as T3, T4 and T5 were Sub-surface drip irrigation laterals of 12mm size with inline drippers laid at varied depths such as ½ feet, 1 foot and 1½ feet depths from the surface of the soil placed inside the soil near to the rhizosphere zone of tree mulberry plants.

The experimental plots were maintained in irrigated & partial irrigated conditions by giving flood irrigation with 1.5 acre inch of water and partial irrigation (drip) with 30,000lit/acre/crop and each irrigation with 3-4 days interval. All the plant growth and leaf yield parameters were recorded 70 days after pruning of every crop i.e. for 5 crops in year. For leaf area, 10 healthy leaves were taken from 10 plants selected at random in each replicated plot and the area was calculated through the regression equation area = -2.12+0.68 (LxB)[19]. Moisture and chlorophylls contents were estimated from $5^{th}/6^{th}$ leaf from the top[18]. Soil chemical analysis of the experimental plots before and after experimentation was analyzed for pH, electrical conductivity, organic carbon, available nitrogen (N), phosphorous (P) and potassium (K) by standard methods[3,9]. All the plant growth and leaf yield parameters were analyzed using ANOVA with factorial analysis.

RESULTS AND DISCUSSION

During the period under the experimentation, 5 crops plant growth, leaf yield, leaf biochemical analysis and soil analysis data recorded was compiled, pooled data was subjected to ANOVA and presented. The mulberry plant growth and leaf yield was responded significantly well to the sub-surface drip irrigations compared to the surface drip and flood irrigations (**Table 1 & Fig. 1**). It was observed that sub-surface drip irrigation laid at 1½ feet depth (T5) yielded highest leaf yield (10057.08kg/ha/crop) followed by the sub-surface drip irrigations laid at 1 feet (T4) and ½ feet (T3) depths (9865.88 & 9638.06 kg/ha/crop) compared to the flood irrigation (T1- 9565.05 kg/ha/crop). However, surface drip irrigation has resulted in lower yield over all the other treatments recording a leaf yield of 9467.17kg/ha/yr. Similar trend was noticed in case of plant growth and leaf quality parameters. Significant level of improvement was noticed in case of plant height, no. of leaves/ plant and leaf area. Whereas, insignificant variations were noticed in case of and L:S ratio per plant respectively. The above results further confirmed with leaf quality parameters resulting increased levels of leaf quality and nutrition status. Significantly increased levels of leaf moisture and total chlorophylls were recorded irrigations (**Table 2**). The results were in confirmation with the findings made by several workers on various crops[1]in the sub-surface drip irrigations of various kinds compared to the traditional flood irrigation and surface drip[,10].

Further the soil physical parameters such as vertical and horizontal infiltration of drip irrigation and water holding capacity (WHC) and bulk density (BD) further confirmed the advantages sub-surface drip irrigations showing their superiority over traditional flood and surface drip irrigations. Increased levels of water infiltration in the form of vertical, horizontal water percolation, WHC and BD was noticed in all the sub-surface drip irrigations compared to the traditional methods of irrigations (flood & surface drip irrigations) (**Table 3**). The changes of soil moisture, which is related to irrigation method, not only significantly affect the spatial distribution of crop roots and the efficiency of nutrition and water adsorption, but also directly affect the biomass of shoots[5]. Drip irrigation proved to efficiently provide irrigation water and nutrients to the roots of plants, while maintaining high yield production[16].

The reasons may be the advantages involved in the sub-surface drip irrigation methods. It is noticed that the water infiltration is down word instead upward due to gravitational forces of the soil. Inline drips laid in varied depths have an advantage over other methods as because the moisture regimes are exactly remaining near to the rhizopshere zone leading to constant availability of water moisture thereby influencing the plant growth, leaf quality and yield. Further less moisture loss and enhanced moisture holding capacity (MHC) was also noticed in the sub-surface drip methods over other flood and surface drip irrigation. Out of all the sub-surface and other traditional irrigation methods (flood & surface) sub-surface inline drips laid at 1½ feet depth (T5) have shown its superiority as because it is located exactly near to rhizosphere zone of mulberry (**Fig. 3**). The distribution of the water in the soil occurs along the hydraulic gradient between the wet and the dry soil, laterally by means of capillary action and vertically due to gravitation. In sand soil, the water moves more vertically than horizontally[2]. Drip irrigation system should apply water uniformity so that each part of the irrigated area receives the same amount of water. Wetting pattern in the soil and the spatial distribution of soil water depend on soil hydraulic properties, drip discharge rate, spacing and their replacement, irrigation amount and frequency, crop water uptake, rates and root distribution pattern[6]. The crop response to irrigation methods was often different[22] and the effect of irrigation development of crop root systems also differed from irrigation technique to another because of differences in soil water regimes. However, no marked various was noticed in case of initial and after experimentation of mulberry soils in varied treatments in case of soil reaction, salinity and nutrient parameters under varied irrigation and micro-irrigation methods (Fig. 3). The reasons may be because of effective nutrient use efficiency promoted by the increased available moisture at subsurface region due to sub-surface irrigation[8,17]. Goyal[7] noticed that shallow type of rooting due to surface irrigation where as deep root penetration was noticed in sub-surface drip irrigation methods.

Table 1: Influence of micro irrigations on the plant growth and leaf yield of mulberry.

Treatments	Plant height (cm)	No. of branch/ plant	No. of leaves/ plant	Leaf area/ cm^2	L:S Ratio (%)	Leaf yield (kg/ha/cr)
T1- Flood Irrigation (Control)	159.3	8.2	265.8	183.8	62.20	9565.05
T2- Surface Drip Irrigation	157.8	8.0	266.2	184.2	62.45	9467.17
T3- Sub-surface Drip Irrigation (at ½ ft depth)	160.2	8.9	274.4	190.2	63.04	9638.06
T4- Sub-surface Drip Irrigation (at 1 ft depth)	161.0	9.2	282.4	192.2	63.55	9865.88
T5-Sub-surface Drip Irrigation (at 1½ ft depth)	163.6	9.4	290.5	198.9	66.90	10057.08
CD at 5%	**4.60**	**N.S**	**1.05**	**6.8**	**N.S.**	**495.05**

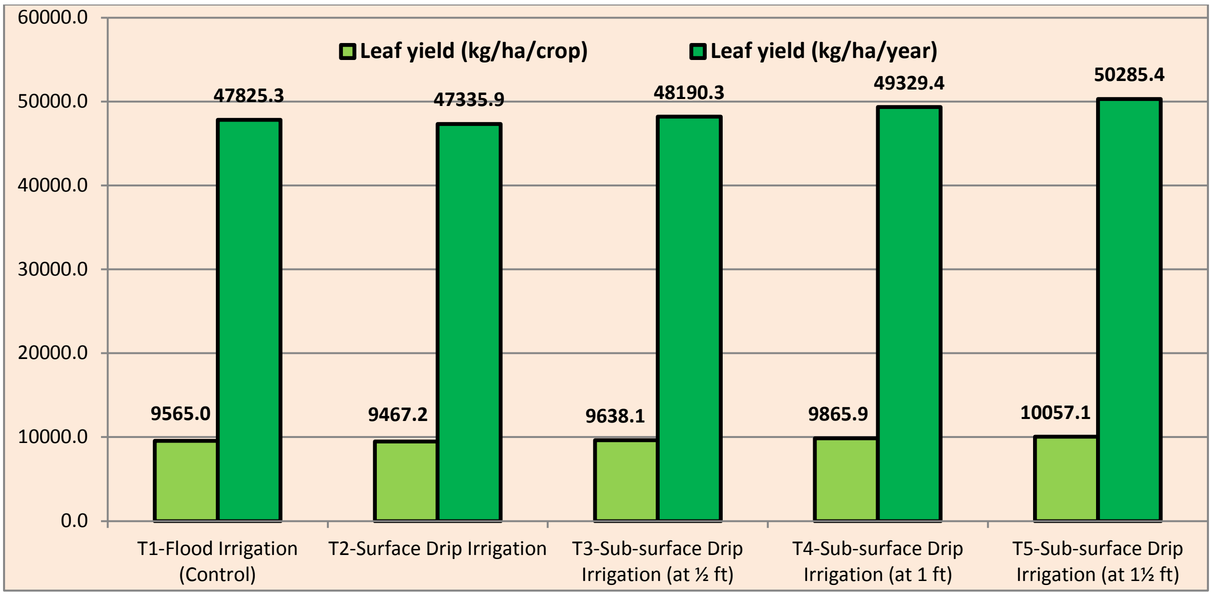

Fig. 1: Annual leaf yield of mulberry as Influenced by various micro irrigation technologies

Table 2: Influence of various kinds of micro-irrigation technologies on leaf nutrition and quality of mulberry

Treatment	Biochemical status of mulberry leaves			
	Moisture (%)	Chlorophyll-a (mg/g)	Chlorophyll-b (mg/g)	Total Chlorophylls (a+b) (mg/g)
T1- Flood Irrigation (Control)	75.28	2.29	0.69	2.98
T2- Surface Drip Irrigation	75.62	2.31	0.70	3.01
T3- Sub-surface Drip Irrigation (at ½ ft depth)	76.40	3.05	0.81	3.86
T4- Sub-surface Drip Irrigation (at 1 ft depth)	76.96	3.65	1.03	4.68
T5-Sub-surface Drip Irrigation (at 1½ ft depth)	77.54	3.75	1.86	5.61
CD at 5%	**0.82**	**0.11**	**0.06**	--

Table 3: Influence of micro irrigations on the water infiltration and soil physical characters of mulberry

Treatments	Water Infiltration		Soil physical characters	
	Vertical (cm)	Horizontal (cm^2)	*WHC (%)*	Bulk Density (g/cc)
T1- Flood Irrigation (Control)	32.05	1046.8	28.15	1.34
T2- Surface Drip Irrigation	26.46	1432.6	26.85	1.26
T3- Sub-surface Drip Irrigation (at ½ ft depth)	32.15	1679.9	27.15	1.29
T4- Sub-surface Drip Irrigation (at 1 ft depth)	38.25	2198.8	29.21	1.32
T5-Sub-surface Drip Irrigation (at 1½ ft depth)	46.95	2205.5	30.05	1.33

WHC= water holding capacity; *Average values of 5 crops harvested.

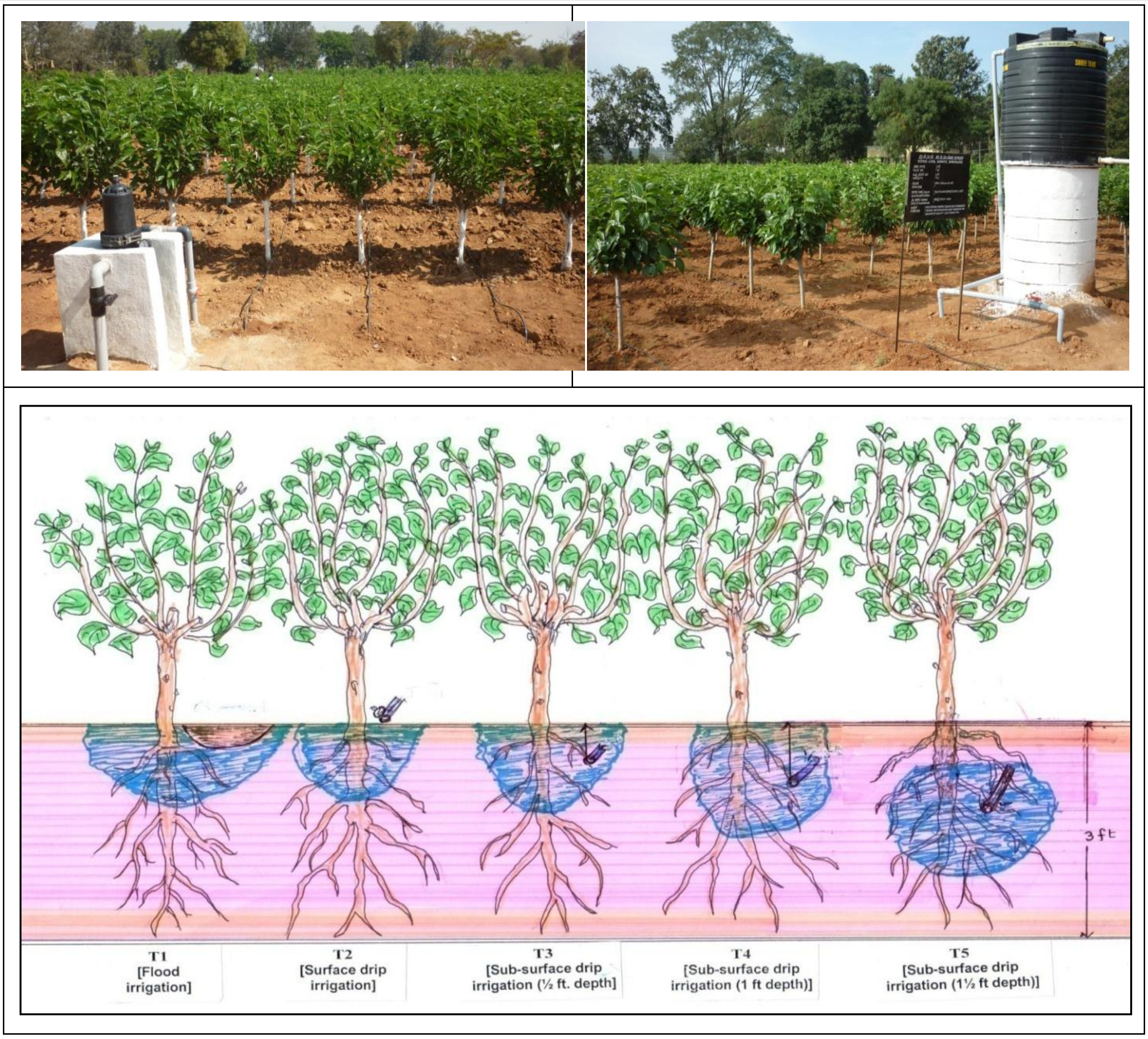

Fig. 3: Tree mulberry with drips and water infiltration scenario in the rhizosphere zone of mulberry in varied irrigations

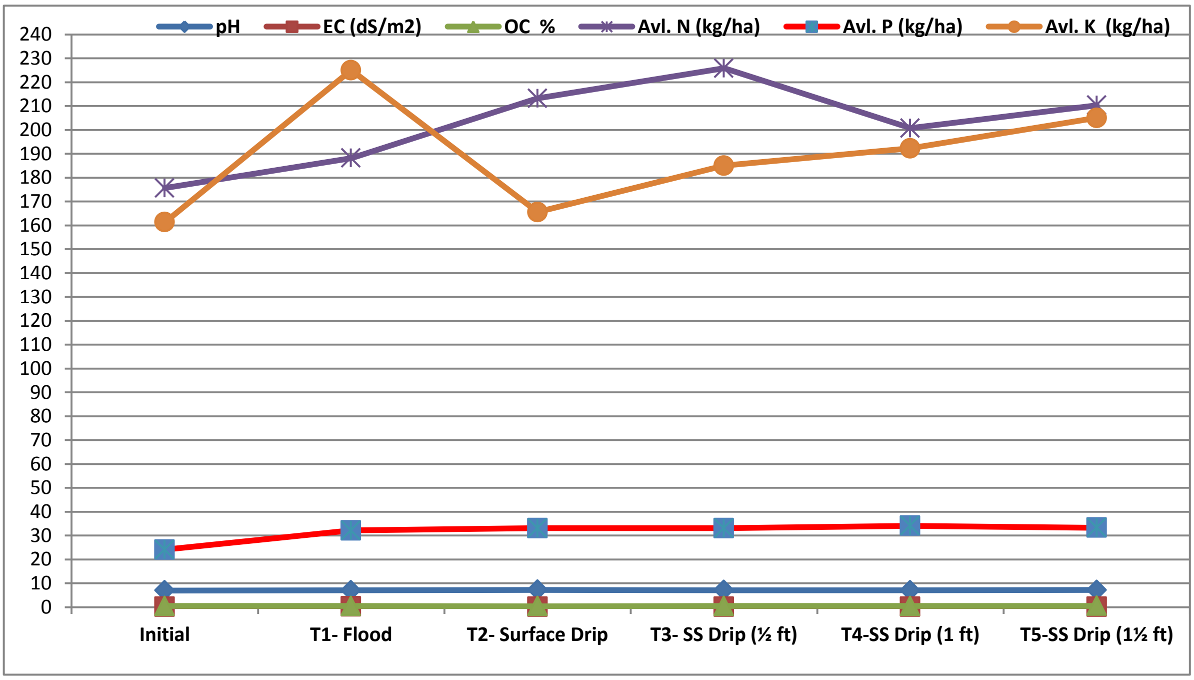

Fig. 3: Impact of varied irrigations on soil reaction, salinity and nutrient status of mulberry

CONCLUSION

On the basis of the present study, it can be inferred that response of sub-surface (SDI) method in red clay and sandy loamy soils of mulberry in Karnataka is positive with respect to its growth, yield, and water use efficiency. It could be concluded that mulberry, being a deep rooted perennial crop and cultivated in tree farms if imparted micro irrigation technologies specially SDIs instead surface drip methods will not only save the irrigation water, reduce the frequency of irrigation and seepage accompanied with plant nutrients but are effective because of their close association with rhizosphere zones of mulberry and making use of water efficiently. Subsurface drip has also proven to be an efficient irrigation method with potential advantages of high water use efficiency, fewer weed and disease problems, less soil erosion, efficient fertilizer application, maintenance of dry areas for tractor movement at any time, flexibility in design, and lower labor costs than in a conventional drip irrigation system. However, there are also some disadvantages with SDI, which mainly relate to poor or uneven surface wetting, blockage of drips and risky crop establishment[15].

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