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Solar Drip Irrigation Kit (SDIK) Sustaining the Mulberry Productivity under Rainfed Sericulture

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Abstract— *In recent years, mulberry becomes one of the important cash crops in India and it is the only sole food crop to feed the silkworm (Bombyx mori).Water scarcity creates significant impact on quality mulberry leaf production which in turn determines the silk productivity. Importantly, rainfed sericulture contributes majorly to the overall silk production in the country. But inconsistence and erratic rainfall pattern greatly affects the mulberry productivity and its sustainability. Maintaining adequate soil moisture in the plant root zone is one of the important agronomic practices in order to obtain higher mulberry productivity in rainfed sericulture. In this context, run-off rain water in the farm can be collected and stored in the surface tank or farm pond for future supplemental irrigation during non-rainy season. A device with solar pump based drumkit drip irrigation system has been developed for effective irrigation management in the rainfed mulberry cultivation. It is an eco-friendly and efficient system to supply the water and nutrients directly at the plant root zone. The study was undertaken at Central Sericultural Research and Training Institute, Berhampore with an objective to explore the effect of solar drip irrigation technology on mulberry productivity. Solar drip irrigation system was established in the experimental garden as follows: a) a water drum of approximately 1000 litre capacity was placed at a height of 5 feet from the above ground level b) From the water drum, water was conveyed to the main field using PVC pipes after filtering through screen filter c) One conventional inline drip lateral (12 mm OD; 2.4 lph) was fixed in every mulberry row with a lateral spacing of 90 cm d)Surface storage tank was constructed to collect and store the run-off rainwater. e) 0.25 HP solar based nano pump was used for lifting water from surface tank to the overhead water tank. f) 80 Wp solar photovoltaic panel was installed to generate solar electricity in order to run the solar nano pump. The experiment consisted of three irrigation systems: Solar Drip Irrigation Kit (SDIK), Conventional Drip Irrigation (CDI) and Surface Irrigation (SI). SDIK system was performed at par with CDI system in terms of mulberry growth and yield attributes. There was 37% improvement in SDIK in leaf yield against SI. Moreover, when water applied through SDIK resulted in the water saving by 24% as compared to that of SI. Besides, significant improvement in water productivity by 44% was recorded in comparison to SI. The present study clearly indicated that SDIK is an innovative approach for efficient irrigation management in order to sustain the mulberry productivity in the rainfed areas. This system would be highly suitable and affordable to small and marginal rainfed sericulture farmers.*

Keywords— ***Solar drip irrigation kit; leaf yield; water productivity; water saving; mulberry***

I. INTRODUCTION

Mulberry is one of the most important commercial crops grown extensively as food plant for silkworm. In India, mulberry is cultivated in about three lakh hectares in different agro climatic conditions varying from temperate to tropical. Sericulture is mainly depends on the quantity and quality of mulberry leaf. India is the second largest producer of silk in the world. Importantly, rainfed sericulture contributes significantly to the total raw silk production in the country which primarily depends on the monsoon rainfall (June–October). However, distribution of rainfall pattern plays a vital role on the rainfed crop productivity. Because of uncertainty in rainfall, delay in onset of monsoon and prolonged dry spells between two rainfall often creates deficit soil moisture in the rainfed mulberry garden which reflects on leaf productivity. Therefore, limited crop yield and inadequate availability of water coupled with uncertain rainfall steers for sustainable water management strategies in rainfed regions to enhance the mulberry productivity. Rain water harvesting in small ponds and recycled as life saving irrigation/supplemental irrigation is a common practice followed to attain sufficient soil moisture for successful rainfed crop production (Oweis et al. 1999). However, the major constraint in recycling of water is lifting of water from the pond and distributes the same in to the field. Importantly, the majority of small farm holders lives in rural areas and have limited access to fuel and electricity. This means they require solar power source for lifting water for irrigation.

Solar drip irrigation kit (SDIK) is one of the most promising technologies for sustainable water management to the small farm holder in the rainfed areas. It is an effective and efficient method of irrigation for higher water use efficiency and water productivity besides energy saving(Roblin, 2016). Several studies suggested as drip irrigation increased crop yield by 20-40% (Banana, Guava and Tomato); saved water by 20-30%; improved water use efficiency by 50% (Sivanappan, 1994). Increasing sustainable, efficient irrigation methods among small farm holders can enable them to increase crop productivity and household incomes (Fiona et al. 2022). In order to achieve sustainable mulberry leaf productivity, there is a need to adopt solar powered drip irrigation in rainfed sericulture farming. Therefore, the aim of this study was to evaluate the impact of solar drip irrigation kit on mulberry productivity.

II. MATERIALS AND METHOD

The present study was carried out at CSRTI, Berhampore (Latitude 24º 05' N and Longitude88º 15' E), West Bengal, India. The experimental site lies in the Gangetic alluvial plains with tropical wet and dry climate with an annual mean temperature of 27°C and monthly mean temperature ranged between 19°C and 35°C. The average annual rainfall and temperature stand at 1344 mm and 26.2°C, respectively, in Berhampore, Murshidabad. The experimental plot initial soil nutrient status was recorded as pH (7.50), EC (0.94 dS m^{-1}), organic carbon(1.44 %), available nitrogen (355 kg ha^{-1}), available phosphorous (78 kg ha^{-1}) and available potassium (660 kg ha^{-1}).

Experimental details

12 year-old S1635 mulberry garden was utilized with 90cm×90 cm spacing. A total of eight crops were harvested in different seasons(June–August2017;September–November2017;January–March 2018; March–May 2018; June–August 2018; September–November 2018; January–March2019;April–June2019).The experiment consists of three irrigation systems: Solar Drip Irrigation Kit(SDIK), Conventional Drip Irrigation(CDI) and surface irrigation(SI).

a. Solar Drip irrigation Kit (SDIK)

Under this system, a small surface tank was constructed in order to store the rain water. Two solar photovoltaic panels (40 Wp) were installed near the surface tank to generate the solar electricity. 0.25 HP solar nano pump was used for lifting water from the surface tank to a overhead tank (1000 litres) placed at1.8 m height on a platform. From the overhead tank, water was conveyed to the main field using PVC pipes after filtering through screen filter. From the mainline, sub mains of 40 mm diameter PVC pipes were connected. Conventional inline drip lateralsof12 mm OD was fixed in the submains with alateralspacingof3feet.One inline drip lateral was placed at 10 cm depth from the surface in every mulberry row. Drip laterals had emitting point spaced at 30 cm apart with a discharge rate of 2.4 lph. Laterals end were closed with end cap. Water was applied to mulberry plantation through drip irrigation by gravity method.

b. Conventional Drip Irrigation (CDI)

Under this system, water was pumped from bore well using electric motor pump and conveyed to the main field using PVC pipes after filtering through screen filter. From the mainline, sub mains of 40 mm diameter PVC pipes were connected. Drip tape laterals of 16 mm OD (250 micron wall thickness of seamless tube) was fixed in the sub mains with a lateral spacing of 90 cm. One drip tape lateral(16mm)was placed at10cm depth from the surface in every

mulberry row. Drip tape laterals had emitting point spaced at 45 cm apart with a discharge rate of 8 litres per hour. Laterals end were closed with end cap. Water was applied to mulberry plantation through drip irrigation by electrical pump pressure.

Mulberry garden maintenance

Bottom pruning (Stump height: 15–20 cm from the ground level) were adopted as per the recommended practices for Eastern India (Setua 2006). Weed control was achieved through light digging and cleaning at periodical intervals. The recommended FYM(8 t ac^{-1}) was applied after digging and properly incorporated in the soil. Drip irrigation was scheduled on every alternate day with 100% Pan Evaporation. Whereas, surface irrigation was given once in ten days at the rate of 1.5 acre inch.

Data collection

Yield and quality attributes

Yield and quality attributes were recorded at 70 days after pruning from the ten randomly selected plants. Number of leaves per shoot and number of shoots per plant was counted and expressed in numbers. Maximum shoot length was measured from the base of the plant to the base of the fully opened leaves and expressed in cm. Leaf yield (g $plant^{-1}$) was estimated by plucking out all the leaves from each plant and the green leaves were weighed by using electronic balance. Leaf yield (t ac^{-1} yr^{-1}) was obtained by multiplying leaf weight per plant and total number of plants per acre.

Water productivity

Water productivity (WP) is quantity of water required to produce one kilogram of mulberry leaf (Viets1962) and calculated as water productivity (lit kg^{-1}leaf) = Volume of water (lit) (1acmm)/ Leaf yield (kg ac^{-1})

Statistical analysis

The mean data of eight crops were subjected to statistical analysis by analysis of variance method. Wherever the treatment differences were found significant (F test), critical difference was worked out at 5% probability level. In case the treatment differences were not significant, denoted as NS.

III. RESULT AND DISCUSSION

Drip irrigation delivers water directly to the roots of plants, thereby improving soil moisture conditions; in many studies, this has resulted in yield gains of up to 50-100% (Mahesh et al. 2013),water savings of up to40–80% (Maheshetal.2016),water productivity enhancement by 60-120% (Yang et al. 2023) and associated fertilizer, pesticide, and labour savings over surface irrigation systems. However,solar drip irrigation kitis an appropriate technology that Can promote sustainable crop productivity in the rainfed areas (Kumar et al. 2015); this study quantifies the impacts of SDIK on leaf yield and water productivity in mulberry.

Different growth and yield parameters like number of shoots, maximum shoot length, number of leaves and leaf yield per plant were markedly influenced by various treatments in the present study. The values of these growth and yield attributes were higher in SDIK and CDI treatments than SI. Further, SDIK significantly improved the growth and yield parameters than SI but it was comparable with CDI. These results are in agreement with Seenappa et al. (2015) who reported that drip irrigation recorded higher yield attributes in mulberry than surface irrigation. Aruna devi et al. (2016) reported that drip irrigation significantly improved the plant height, number of branches per plant and number of leaves per branch compared to that of surface irrigation. The increments in shoot number, shoot length and number of leaves were45 & 50%, 30 & 29% and 37 & 36%, respectively in SDIK and CDI than SI in the present study. Better performance of mulberry under drip irrigation might be due to maintenance optimum soil moisture around the root zone through the cropping period which might facilitated for better water uptake led into quick plant growth and development.

Irrigation with SDIK and CDI recorded the highest leaf yield and the least yield was obtained from the SI in all the seasons. Increment in mean leaf yield was 37 and 36%higherin SDIK and CDI, respectively as compared to SI. Dingre et al. (2012) reported that drip irrigation enhanced the onion crop productivity by 12% over to that of SI. According to Naik et al. (2021), solar pump with drip irrigation system increased Chilli yield by 23%, reduced energy consumption by 545 kWh and also increased net income of the farmer in Karnataka.

The improvements in leaf yield under SDIK and CDI systems was mainly due to irrigating the crop as per its requirement at different growth stages might have maintained the soil with optimum soil moisture and higher oxygen concentration in the active root zone which led into results of better water utilization, higher nutrients uptake and crop yield. Jennifer et al. (2010) reported that solar powered drip irrigation significantly augments water intake, crop yield and household income during the dry season. Further, leaf yield was not statistically differed between SDIK and CDI in the present study. This showed that SDIK is an appropriate technology in order to sustain the mulberry productivity in the rainfed areas.

Table1.Effect of irrigation systems on growth,leaf yield and water productivity in mulberry

Treatments	Number of shoots per plant	Shoot length (cm)	No. of leaves Per plant	Leaf yield (g $plant^{-1}$)	Leaf yield ($kgacre^{-1}$ yr^{-1})	Total water use (mm)	Water productivity ($litkg^{-1}$leaf)
SDIK	11.07	132.72	18.92	597	14.75	1204	326
CDI	11.50	133.13	19.38	596	14.72	1204	327
SI	7.63	103.13	15.08	437	10.79	1575	584
CD	1.26	12.93	2.06	67.94	1.26	-	45
SDIK-Solar Drip Irrigation Kit; CDI-Conventional Drip Irrigation; SI-Surface Irrigation							

In general, mulberry is a high water consuming crop and it requires around 1600-2000 mm of water annually under surface irrigation method. In the present study, irrigation water requirement for mulberry was only 1204mmin both SDIK and CDI which resulted water saving of 24% as compared to that of SI (1575 mm). Water losses through soil evaporation and percolation are very limited in drip irrigation which could facilitate to save the water. Alaofe et al. (2016) reported that solar drip irrigation improves the farmer's income by enhancing crop yield and water uptake. Water saving of drip system was reported by Mahesh et al. (2022), which is up to 24% as compared to the surface system.

Water productivity is an indicator for the efficiency of irrigation systems. Ran et al. (2018) and Huang et al. (2022) reported that drip irrigation could enhance crop water productivity when compared to furrow irrigation and flooding irrigation methods. WP was found significantly increased under SDIK and CDI systems in the present study. The mean water productivity of mulberry leaf was increased by 56% under SDIK and CDI when compared to that of SI. In this study, both SDIK and CDI methods utilizes only 380 litres of water to produce one kg of mulberry leaf whereas it was 700 litres of water in case of SI method. This indicates both SDIK and CDI are very efficient systems for irrigating water to the mulberry plantation. Drip irrigation system doubled the water productivity in comparison to surface irrigation due to better utilization of water and nutrients which in turn resulted in higher yield and lesser total water used.

IV. CONCLUSION

Rainfed sericulture's contributions for the domestic and global silk demand are unavoidable. But, the mulberry productivity in the rainfed areas is very limited due erratic rainfall patterns under changing climatic conditions. Therefore, recycling of rain water for supplemental irrigation to the rainfed mulberry crop is need of the hour in order to enhance the mulberry leaf productivity. In this connection, the impact of SDIK on rainfed mulberry leaf productivity was studied. SDIK resulted improvement in leaf yield by 37% and water productivity by 44% as compared to surface irrigation. Thus the above mentioned facts establish that SDIK could be an appropriate technology for sustainable mulberry productivity to the small-scale sericulture farmers in the rainfed areas.

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