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Yield and Quality of Mulberry Leaf and Cocoon Influenced by Different Methods, Levels of Irrigation and Mulching During Summer in Eastern Dry Zone of Karnataka

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Abstract – **A field experiment was conducted at College of Sericulture, Chintamani, Chickaballapur district, Karnataka, India during summer 2014 to study the influence of different methods, levels of irrigation and mulching on yield and quality of mulberry leaf and silkworm cocoons. The results showed that yield and quality of leaf and cocoons were significantly influenced by different methods, levels of irrigation and mulching. Among methods of irrigation, subsurface drip irrigation recorded higher chlorophyll, relative water content, leaf yield, cocoon yield and filament length (9.74, 74.62%, 43903kg ha^{-1} yr^{-1},59.63 kg/100 DFLs and 748.70 m) respectively, than surface drip (8.52, 72.02%, 37894kg ha^{-1} yr^{-1}, 55.17 kg/100 DFLs and 701.87 m) and micro spray jet (8.66, 72.34%, 38354kg ha^{-1} yr^{-1}, 57. 55.23 kg/100 DFLs and 688.70 m). Among the levels of irrigation, higher level of irrigation (1.0 CPE) was found to be best in improving chlorophyll, relative water content, leaf and cocoon yield and filament length (9.91, 75.48%, 45082kg ha^{-1} yr^{-1}, 61.00 kg/100 DFLs and 756.17 m) compared to lower levels of irrigation (0.6 and 0.8 CPE). Maximum chlorophyll, relative water content, leaf yield, cocoon yield and filament length (9.16, 73.55%, 40735 kg ha^{-1} yr^{-1},57.45 kg/100 DFLs and 725.15 m) was recorded in mulching treatment than without mulching. It would be concludedthat subsurface drip irrigation at 1.0 CPE with mulching increased the yield and quality of mulberry leaf and cocoon than surface drip and micro spray jet irrigation. Hence, subsurface drip irrigation may be more appropriate to attain higher quality and quantity in mulberry leaf and cocoon production in Eastern Dry Zone (EDZ) of Karnataka.**

Keywords – **Surface Drip, Subsurface Drip, Micro Spray Jets, CPE, Mulching, Mulberry.**

I. Introduction

Mulberry (*Morus alba*L.) is cultivated for its leaves and is the sole food for silkworm (*Bombyx mori* L.). Mulberry can grow both in the tropics and temperate regions. It is comparatively resistant to climatic variations and can be cultivated in different soil types under both rainfed and irrigated conditions. Total area of mulberry in India is 2.82 lakh hectares and in Karnataka is 1. 66 lakh hectares (Vijayan*et al.,* 2009). About 80% and 95% of mulberry area in India and Karnataka is under irrigated conditions, indicating the importance of irrigation for mulberry crop production. Different factors responsible for a successful cocoon crop are mulberry leaf (38.2%), climate (37%), rearing technique (9.3%), silkworm race (4.2%), silkworm eggs (3.0%) and other factors (8.2%) (Miyashita, 1986). It indicates that the quantity and quality of leaf produced per unit area have a direct effect on quantity and quality of cocoons. The yield and quality of mulberry leaf and cocoons are entirely depends on maintenance of soil moisture and fertility status of mulberry garden.

Silkworm (*Bombyx mori* L.) is essentially monophagous insect feeds only on mulberry leaves (*Morus* spp.). Leaf quality is an important parameter used for selection of superior varieties of silkworms (Bongale*et al.*, 1997). It is fact that, in sericulture more than 60% of total cost of cocoon production goes towards mulberry production alone. Hence, in recent years maximum attention has been given for the improvement of quality and quantity in mulberry. Growth and development of silkworm and cocoon yield are mainly influenced by yield and nutritional quality of mulberry leaf used (Yokoyama, 1963).

Water is the critical and costly input for mulberry crop production and is the most limiting factor in Indian agriculture. Though India has the largest irrigation area, irrigation efficiency has not been achieved more than 40%. Per capita water availability in the country has dropped from 6008 m^3 in 1947 to 1250 m^3 now and is expected to dwindle down to 760 m^3 (Singh, 2006). Among all the agronomical inputs, irrigation water has highest impact on mulberry leaf quantity and quality. The need of the hour is to maximize the production per unit of water. Hence, further improvement in quality and quantity of crops may need to adopt new irrigation systems such as subsurface drip irrigation. Subsurface drip irrigation supplies water and nutrients directly to the crop root zone. Crops can be “spoon-fed” water and nutrients. The spoon-feeding characteristic of the subsurface drip irrigation system has a great potential to minimize the water losses.

Mulching is one of the important agronomic practice essential for conserving the soil moisture, suppressing the weeds, improving soil fertility and modifying the soil physical environment (Yoo-Jeong*et al.*, 2003). Different types of mulches have been used to obtain good crop yield and quality. In the above context, present study conducted to evaluate suitable method and level of irrigation for mulberry and cocoon production in EDZ of Karnataka since this zone is traditional sericulture belt.

II. Materials and Methods

The study was conducted during summer 2014 in pre-established irrigated V-1 mulberry garden at College of Sericulture, Chintamani, Chickaballapur district, Karnataka state, India. Climate is semi-arid, tropical with hot dry summer and cold winter and it falls in EDZ of Karnataka. Annual rainfall is 650-700 mm.The experiment was laid out in a split-split plot design with three replications and 18 treatments combination comprises three methods of irrigation (I_1= surface drip, I_2 = subsurface drip and I_3 = micro spray jet), mulching (M_1 = with mulching and M_0 = without mulching) and three levels of irrigation (L_1 = 0.6 CPE, L_2 = 0.8 CPE and L_3 = 1.0 CPE). In drip irrigation method in-line drip laterals were connected to sub-mains at a spacing of 1 m and laid on surface all along the rows and in-line drippers are placed on lateral tubes with discharge rate of 2.5 lph. Plots irrigated with subsurface drip irrigation system, in-line drip lateral tubes were buried into the soil at 5-10 cm away from rows to a depth of 15-20 cm. In micro spray jet irrigation system, micro spray jets were fixed at a spacing of 1 m 30 cm raisers at the middle of four plants. First one blank irrigation was given to all plots two days prior to starting of experiment to bring the soil moisture to field capacity. Subsequent irrigation were given once in three days and different levels of irrigation were imposed on the basis of cumulative pan evaporation through climatological approach (Jenson *et al.,* 1961). Fully dried weeds and other crop residues were spread over the ground as mulch at the rate of 30 kg per treatment. Recommended FYM of 15 t ha^{-1} was incorporated in to the soil at ploughing and nitrogen, phosphorus and potassium (350:120:120 NPK kg ha^{-1}) were supplied to all the plots through fertigation. The cultural practices were followed as per the recommended package of practices (Dandin *et al*., 2003). Five plants were randomly selected in each treatment for recording leaf yield.

Silkworms were reared to find out the influence of different methods and levels of irrigation and mulching on cocoon yield and quality. For each treatment, one egg laying of PM x CSR_2 cross breed was reared and three replications were maintained. Shoots were harvested during cooler hours of the day and preserved in wet gunny cloth till the feeding time. Larvae were fed daily twice (7 am and 7 pm) with healthy, fresh mulberry leaves. Young age larvae were fed with tender, succulent, nutritious leaves, while mature and coarse leaves were fed to larvae when they grow till ripening. Cocoons were collected on 5^{th} day of mounting and were assessed for quality parameters viz., cocoon weight, length of filament, weight of filament and denier. Data was statistically analyzed by adopting O.P. Stat software. Treatment means and interaction effects were compared using critical difference at 5% level of significance.

III. Results and Discussion

A. Leaf yield and quality

There were significant effect of different methods, levels of irrigation and mulching on leaf yield and quality of mulberry presented in Table 1. Subsurface drip irrigation recorded higher chlorophyll, relative water content and leaf yield (9.74, 74.62% and 43903 kg ha^{-1} $year^{-1}$) may be due to reducing evaporation losses and spoon feeding of water and nutrients to plants compared to surface drip (8.52, 72.02% and 37894 kg $ha^{-1}year^{-1}$) and micro spray jet (8.66, 72.34% and 38354 kg ha^{-1} $year^{-1}$) irrigation methods. Chlorophyll content is very important for quantifying the photosynthetic efficiency. These results are in agreement with those of El-Fawakhry (2004) reported that the drip irrigation is important in increasing the availability and absorption of nitrogen and other minerals in the plant, thereby increasing the chlorophyll content in the leaves. Sujathamma and Dandin (2000) also reported that the increased amount of chlorophyll in leaves indicates the photosynthetic efficiency. Subsurface drip irrigation was more efficient than surface drip irrigation for enhancing quantitative and qualitative growth parameters and nutrient concentrations in plants and fertility in the soil was reported by Khalid (2012). Palese*et al*., (2009) and Hussein (2008) were reported that increased in quantity of leaf might be due to increase photosynthetic rate as a result of more absorption of available nutrients, which cause an increase in growth and photosynthesis efficiency. Further, the yield of date palms was increased by 45 and 48% under sub surface drip irrigation as compared with surface drip irrigation (Talat*et al.,* 2012).

Mulberry crop irrigated at higher level of irrigation (1.0 CPE) recorded higher chlorophyll, relative water content and leaf yield (9.91, 75.48% and 45082 kg ha^{-1} $year^{-1}$) compared to lower levels of irrigation at 0.8 CPE (9.00, 73.69% and 40844kg ha^{-1} $year^{-1}$) and 0.6 CPE (8.01, 69.81% and 34225 kg ha^{-1} $year^{-1}$). Higher level of irrigation increased leaf quality and quantity because of more availability of soil moisture in the root zone resulting in more uptake of nutrients resulted in more chlorophyll content, increased photosynthetic activity and more dry matter production and accumulation which enhanced leaf yield. Khattab*et al*., (2011) observed that the increment in irrigation rate was concurrent with an increase in chlorophyll, could be attributed to increased nutrient uptake especially N and Mg as a consequence of improved soil moisture. Similar results were also reported by Bongale and Siddalingaswamy (2003) that among the levels of irrigation 0.9 CPE showed higher leaf yield (9-21%), higher leaf moisture content and higher leaf nitrogen content in mulberry.

Mulching recorded significantly higher chlorophyll, relative water content and leaf yield (9.16, 73.55% and 40735 kg ha^{-1} $year^{-1}$) than without mulching (8.79, 72.44% and 39366 kg ha^{-1} $year^{-1}$) treatments. Similar results were also reported by Ramakrishna *et al*., (2006) that the beneficial aspects of mulching includes conservation of moisture, controls weeds and moderate soil temperature for better root growth and higher crop yield. Mulching also increase the availability of more moisture and reduced soil temperature which increases the activity of the soil microbes might also helped in increasing yield and quality parameters. However, the chlorophyll, relative water content and leaf yield were found non-significant due to the interaction effect between methods and levels of irrigation and mulching.

B. Cocoon yield and quality

Cocoon yield and quality were significantly influenced by different methods, levels of irrigation and mulching (Table. 2). Maximum cocoon yield and filament length (59.63 kg/100 DFLs and 748.70 m) were recorded in cocoons obtained by rearing silkworms on leaves produced in subsurface drip irrigation than surface drip (55.17 kg/100 DFLs and 701.87 m) and micro spray jet (55.23 kg/100 DFLs and 688.70 m) irrigation methods. This might be due to feeding of quality mulberry leaf had beneficial effect on quality and quantity of cocoons. Ajay Koul*et al.,* (1996) reported that in mulberry leaves moisture content plays a vital role in improving nutrition levels which in turn improve the palatability and digestibility of leaves in silkworms improves normal growth and development of silkworms and cocoons quality.

Higher cocoon yield and filament length (61.00 kg/100 DFLs and 756.17 m) were found in cocoons harvested from rearing silkworms on leaves grown in higher level of irrigation at 1.0 CPE compared to lower of level of irrigation at 0.8 CPE (57.36 kg/100 DFLs and 723.31 m) and 0.6 CPE (51.67 kg/100 DFLs and 659.79 m). And also cocoons harvested from silkworms reared on leaves raised with mulching recorded significantly higher cocoon yield and filament length and weight (57.45 kg/100 DFLs and 725.15 m) than without mulching (55.90 kg/100 DFLs and 701.03 m) may be due to conservation of soil moisture by reducing evaporation losses and creating a favourable microclimate. Higher leaf moisture content and nutritive value of mulberry leaf are significantly associated with the growth and nutritional parameters of silkworm and cocoon yield besides environment and technology adoption for better silkworm cocoon crop (Rahmathulla*et al.,* 2004 and Yoganandamurthy*et al.,*2013). However, non-significant differences were observed in cocoon yield and filament length due to interaction effects of methods and levels of irrigation and mulching.

IV. Conclusion

Subsurface drip recorded higher yield and quality of leaf than surface drip and micro spray jet irrigation due to spoon feeding of nutrients and water to plants have a direct effect on production of high quality cocoon. Hence, subsurface drip irrigation may be appropriate and efficient method to achieve good quality and quantity of leaf and cocoon production in EDZ of Karnataka under water scarce situations.

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Table 1: Yield and quality of mulberry leaves as influenced by different methods, levels ofirrigation and mulching during *summer* 2014

Treatments	Chlorophyll content			RWC (%)			Leaf yield (kg $ha^{-1}yr^{-1}$)		
	Mulching (M)								
	M_1	M_0	Mean	M_1	M_0	Mean	M_1	M_0	Mean
Irrigation Methods (I)									
I_1	8.75	8.29	**8.52**	72.72	71.31	**72.02**	38791	36997	**37894**
I_2	9.86	9.63	**9.74**	74.82	74.41	**74.62**	44352	43454	**43903**
I_3	8.89	8.44	**8.66**	73.09	71.59	**72.34**	39061	37647	**38354**
Mean	**9.16**	**8.79**		**73.55**	**72.44**		**40735**	**39366**	
	S.Em±	**C.D.**		**S.Em±**	**C.D.**		**S.Em±**	**C.D.**	
Irrigation Methods (I)	**0.32**	**NS**		**0.45**	**1.76**		**364**	**1421**	
Mulching (M)	**0.24**	**NS**		**0.51**	**NS**		**270**	**931**	
I x M	**0.41**	**NS**		**0.89**	**NS**		**467**	**NS**	
Levels of Irrigation (L)									
L_1 **0.6 CPE**	8.22	7.80	**8.01**	70.45	69.16	**69.81**	34801	33649	**34225**
L_2 **0.8 CPE**	9.12	8.89	**9.00**	74.08	73.29	**73.69**	41568	40121	**40844**
L_3 **1.0 CPE**	10.15	9.67	**9.91**	76.11	74.85	**75.48**	45836	44328	**45082**
Mean	**9.16**	**8.79**		**73.55**	**72.44**		**40735**	**39366**	
	S.Em±	**C.D.**		**S.Em±**	**C.D.**		**S.Em±**	**C.D.**	
Levels of Irrigation (L)	**0.31**	**0.91**		**0.67**	**1.97**		**593**	**1731**	
M x L	**0.44**	**NS**		**0.95**	**NS**		**838**	**NS**	
	Levels of Irrigation (L)								
	L_1	L_2	L_3	L_1	L_2	L_3	L_1	L_2	L_3
Irrigation Methods (I)									
I_1	7.89	8.47	9.20	69.53	71.92	74.60	33604	37472	42605
I_2	8.32	9.97	10.94	70.88	76.33	76.65	36521	46794	48394
I_3	7.83	8.57	9.59	69.02	72.81	75.19	32551	38266	44245
	S.Em±	**C.D.**		**S.Em±**	**C.D.**		**S.Em±**	**C.D.**	
I x L	**0.54**	**NS**		**1.17**	**NS**		**1027**	**2998**	
I x M x L	**0.77**	**NS**		**1.65**	**NS**		**1452**	**NS**	

C.D. @ 5%
M_1 = With mulching
M_0 =Without mulching
I_1 = Surface drip
I_2 = Subsurface drip
I_3 = Micro spray jet
RWC = Relative Water content
CPE = Cumulative pan evaporation
NS = Non-significant

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Table 2: Yield and quality of cocoons as influenced by different methods, levels of irrigationand mulching during *summer*2014

Treatments	Cocoon yield (kg/100 DFLs)			Filament length (m)			Filament weight (g)		
	Mulching (M)								
	M_1	M_0	Mean	M_1	M_0	Mean	M_1	M_0	Mean
Irrigation Methods (I)									
I_1	55.88	54.46	**55.17**	713.86	689.88	**701.87**	0.234	0.214	**0.224**
I_2	60.29	58.96	**59.63**	763.19	734.21	**748.70**	0.202	0.173	**0.188**
I_3	56.17	54.29	**55.23**	698.40	679.00	**688.70**	0.179	0.192	**0.186**
Mean	**57.45**	**55.90**		**725.15**	**701.03**		**0.205**	**0.193**	
	S.Em±	**C.D.**		**S.Em±**	**C.D.**		**S.Em±**	**C.D.**	
Irrigation Methods (I)	**0.46**	**1.79**		**3.811**	**14.880**		**0.005**	**0.020**	
Mulching (M)	**0.27**	**0.94**		**5.783**	**19.958**		**0.002**	**0.005**	
I x M	**0.47**	**NS**		**10.016**	**NS**		**0.003**	**0.009**	
Levels of Irrigation (L)									
L_1 0.6 CPE	52.50	50.84	**51.67**	677.47	642.11	**659.79**	0.223	0.189	**0.206**
L_2 0.8 CPE	58.21	56.50	**57.36**	726.45	720.17	**723.31**	0.198	0.193	**0.196**
L_3 1.0 CPE	61.63	60.38	**61.00**	771.53	740.82	**756.17**	0.194	0.198	**0.196**
Mean	**57.45**	**55.90**		**725.15**	**701.03**		**0.205**	**0.193**	
	S.Em±	**C.D.**		**S.Em±**	**C.D.**		**S.Em±**	**C.D.**	
Levels of Irrigation (L)	**0.54**	**1.59**		**5.927**	**17.304**		**0.002**	**0.007**	
M x L	**0.77**	**NS**		**8.382**	**NS**		**0.004**	**0.010**	
	Levels of Irrigation (L)								
	L_1	L_2	L_3	L_1	L_2	L_3	L_1	L_2	L_3
Irrigation Methods (I)									
I_1	51.44	55.13	58.94	663.30	711.67	730.64	0.237	0.220	0.217
I_2	53.44	61.32	64.13	701.22	741.29	803.58	0.192	0.187	0.185
I_3	50.13	55.63	59.94	614.85	716.95	734.30	0.190	0.180	0.187
	S.Em±	**C.D.**		**S.Em±**	**C.D.**		**S.Em±**	**C.D.**	
I x L	**0.94**	**NS**		**10.266**	**29.971**		**0.004**	**NS**	
I x M x L	**1.33**	**NS**		**14.518**	**NS**		**0.006**	**0.018**	

C.D. @ 5% M_1 = With mulching M_0 =Without mulching
I_1 = Surface drip I_2 = Subsurface drip I_3 = Micro spray jet
NS = Non-significant CPE = Cumulative pan evaporation