REVIEW OF LITERATURE
CHAPTER - II

REVIEW OF LITERATURE

Cultivation of mulberry plant is mainly for its leaves the sole food for the silkworm, *Bombyx mori* L. for commercial production of raw silk. The mulberry is cultivated in about 1.84 lakh ha. area in India. Of the total mulberry area above 80% is under irrigation conditions. Where as in Tamil Nadu state out of 14220 ha. mulberry plantation about 95% of garden is under irrigated conditions, which reflect the requirement irrigation for mulberry crop. Irrigation has played a vital role in rapid increase of raw silk productivity per unit area at the farmers’ level and for the total raw silk production at the national level in the last 50 years.

Mulberry requires about 1.5 to 2.0 acre inch water per irrigation at an interval of 6-12 days depending upon the type of soil and seasons and thus about ten irrigations in 65-70 days duration of a crop is required to harvest maximum leaf yield. Thus the annual requirement of irrigation water for five crops is about 75 acre inch equivalent to 1875 mm rainfall distributed equally every week throughout the year @ 36 mm for 52 standard weeks or 5 to 6 mm per day is sufficient for the mulberry crop. But our country’s 80% of average annual rainfall of 1174 mm is received in 4-5 months and in Tamil Nadu the average annual rainfall of 961.8 mm. is received in 40-45 days and hence practically, it is not possible to meet the demand of irrigation for mulberry crop based on rainfall alone.

Most of the irrigation method adopted in mulberry crop at farmers’ level is open system having a relatively low efficiency of water application, where in huge quantity of water loss due to conveyance, seepage and evaporation etc., which in turn results in realization of less than 50% irrigation efficiency by the crop. Further in irrigation, water and labour are the two major limiting factors becoming scarce and highly expensive; to overcome these constraints use of most efficient method of irrigation system at farm level is inevitable. To achieve maximum quality linked
increased leaf productivity and water use efficiency in mulberry crop with minimum water supply following proper irrigation scheduling and application of required quantity of water by mulberry even at low irrigation water input is possible through efficient irrigation management system.

Miyashitha (1986) categorized the various factors contributing for the successful silkworm cocoon crop as mulberry leaves 38.2 %, rearing climate 37.8%, rearing technology 9.3%, silkworm race 4.2%, silkworm eggs 3.1% and other factors 8.2%. As the mulberry leaves' share for the success of the silkworm cocoon crop is at the maximum, production of quality linked increased productivity of the same per unit area at less production cost is important for sustainable sericulture in the field at farmers’ level.

The review of literature collected is presented under the following broad headings:

- Efficiency of Irrigation methods and levels in different crops.
- Soil regime and mulberry growth.
- Mulberry leaf quality and silk production.
- Irrigation in mulberry cultivation.

2.1. EFFICIENCY OF IRRIGATION METHODS AND LEVELS IN DIFFERENT CROPS

2.1.1. IN COTTON:

Increase of seed cotton yield by 10.5% and 30-68% water savings under sprinkler irrigation when compared to furrow irrigation was reported by Nikolaevskaya (1973). Studies made by Kaliappa et al., (1974) revealed that no difference in cotton yield when irrigation scheduled at 100 or 80% ASM in the top 30 cm soil layer and this was supported by Nikolov, (1974). Sivanappan and
Gowder (1974) reported 30% water saving under sprinkler irrigation when compared to flood irrigation without affecting the yield.

Shanmugam et al., (1976) reported that 50% water saving under drip irrigation without affecting the quality of lint with increased yield above half bale when compared to furrow irrigation and this was supported by the studies made by Wilson et al., (1984). Lint yield increased by 7% under drip irrigation when compared to sprinkler irrigation was reported by Bar-Peled and Rimon (1980) and the maximum cotton yield with drip irrigation at water equivalent to 75% of open water evaporation scheduled at 10 mm evaporation was reported by Padmakumari and Sivanappan (1985). Carmi and Plani (1988) reported that main stem height, number of internodes, percentage boll abscission and DM / plant decreased with decreased irrigation rate and highest seed cotton yield and earliest maturity with the lowest irrigation under drip irrigation.

Rymon and Fishelson (1988) observed short-term drip found as the most cost effective technology and sprinklers are non-viable at any input price combination in cotton. Drip irrigation with treated domestic and farm effluent in maize, wheat, and cotton yields are higher than surface irrigation was reported by Oren et al., (1988). Cetin et al., (1994) reported that water savings @ 31, 28, 28 and 27% in drip, sprinkler, mobile nozzle and sub-surface irrigation respectively when compared to furrow irrigation without affecting the yield. Studies made by Srinivasa and Thimmegowda (1997) revealed that maximum yield of 2.48 MT.ha⁻¹ at 75% CPE irrigation and maximum WUE at 25% CPE irrigation with drip in main crop and in ratoon crop the yield was mainly influenced by pruning at 40 cm height.

2.1.2. IN SUGARCANE:

Cane yield increase and water saving was reported under drip irrigation when compared to furrow irrigation was reported by Gibson (1975) and the same was
supported by Shan et al., (1977). Studies made by Hill (1977) revealed 9% cane yield increase and 14% water savings under drip irrigation when compared to furrow irrigation. Ibrahim (1978) observed high economics on cane and sugar yield when irrigation scheduled at 30-40 % ASM. and this was supported by the studies made by Phulare and Upadhyay (1979) and Chavan et al., (1980).

Yamauchi and Bui (1990) reported that drip irrigation saved the Hawaiian sugarcane industry balancing the land and labour constraints with increased yield > 30%. Studies made by Hapase et al., (1992) revealed 50-55% water savings, 12 to 37% yield increase and 3 times more WUE under drip when compared to furrow irrigation and Parikh et al., (1992) reported that drip irrigation equal to 0.3 and 0.6 $E_{pan}$ cane yield of 106.4 & 120.5 MT.ha.$^{-1}$ with 34 and 51.8% increased yield and 7.6 to 50% water savings respectively when compared to 79.4 MT.ha.$^{-1}$ yield under furrow irrigation @ 0.75 IW:CPE.

Shrivastava et al., (1993) reported that sprinkler irrigation @ 0.45 IW:CPE in sugarcane raised in black soil with cane yield of 97.23 MT.ha$^{-1}$ with 22.47% increased yield and 37.5% water saving compared to the yield of 79.39 MT.ha$^{-1}$ under furrow irrigation @ 0.75 IW:CPE.

In cultivated sugarcane variety Co 7219 planted in pit and paired row system, drip irrigation increased the cane yield by 20.83 & 13.9% respectively compared to furrow irrigation yield of 114.7 MT.ha.$^{-1}$ and alternate furrow irrigation yield of 92.1 MT.ha.$^{-1}$ Quality in terms of brix, pol, purity and commercial cane sugar % were best under drip irrigation in paired row system of planting were reported by Kittad et al., (1995). Magar (1995) reported 64.3% water savings and 21.6% yield increase with almost doubled WUE under drip irrigation when compared to surface irrigation and net irrigation water requirement of sugarcane planted in January was estimated as 16, 50 and 30 m$^3$/ha for winter, summer and rainy season respectively.
Ahluwalia et al., (1998) on a trial with surface irrigation @ 0.75, 1.0 & 1.25 IW:CPE and drip irrigations @ 0.4, 0.55 & 0.7 IW:CPE observed yield increase with increase in quantity of water applied. 1.0 IW:CPE irrigation under surface and 0.4 IW:CPE irrigation under drip were found optimum with cane yield of 81.4 & 80.6 MT.ha.\(^{-1}\) and WUE 0.484 & 0.779 MT.ha.\(^{-1}\)cm\(^{-1}\) water applied respectively. Further drip irrigation induced early maturity of the crop with 38% water saving in addition to above WUE increased by 60.9% over surface irrigation was recorded.

Studies made by Shinde and Jadhav (1998) revealed that drip with automatic controlled system saved irrigation water upto 56% and increased the cane yield upto 52% and WUE by 2.5 to 3 fold over surface irrigation. Requirement of chemical fertilizers reduced if applied through drip irrigation and mulch reduced water by further 16% than the conventional irrigation in sugarcane crop

2.1.3. IN WHEAT:

Grain yield increase was reported with increase in number of irrigation scheduled at 50 mm evaporation and irrigation at 60 & 80% ASM. by Gowda and Patil (1973) and Rathore and Singh (1973). Satuvov (1975) reported 35.7% irrigation water savings and 25% yield increase with better quality under sprinkler irrigation.

Soil water depletion increases with amount of irrigation water increased and determination of irrigation schedule at various critical stages of growth increased the grain yield up to 50-100% with 33-50% water savings was reported by Rahman et al., (1980).

Irrigation scheduled at 50% ASM. before flowering thereafter at 70% ASM. gave maximum grain yield of 4.70 MT.ha\(^{-1}\) compared to irrigation water applied at 50% ASM. throughout the crop were observed by Tripathi and Lal (1982). However Lin Qi et al., (1998) reported that irrigation scheduled at 80% ASM. was found
suitable for grain yield formation, exceeding this level reduced the grain yield and further they recorded the requirement of irrigation water for winter wheat year\(^{-1}\) as 9000 mm and 6000 mm to obtain maximum and economic level of grain yield respectively and irrigation water savings at sowing, jointing and grain filling stages.

### 2.1.4. OTHER AGRICULTURE CROPS:

Maximum grain yield obtained in sorghum when irrigation scheduled at 50% ASM. (Kaliappa et al., 1974). Ravelo et al., (1977) reported non significant difference on grain yield and WUE in sorghum with drip and sprinkler irrigation. Clark (1979) reported maximum WUE under drip followed by sprinkler and furrow system of irrigations and to produce equivalent weight of maize drip irrigation system required the least amount of water.

Irrigation level equal to 0.6 or 0.9 IW:CPE ratios in clay soil yielded 3.7 MT.ha\(^{-1}\) as against the control without irrigation yield of 2.36 MT.ha\(^{-1}\) sorghum in kharif season was reported by Dhonde et al., (1986). Irrigation depth of 6 or 8 cm in any different IW:CPE ratios ranging from 0.4 to 1.0, the grain yield difference observed were not significant (Lomte et al., 1988). Irrigation depth equal to < 85% \(E_{TC}\) with sprinkler irrigation observed significant yield reduction in maize. However the yield was not affected when irrigation applied greater than \(E_{TC}\) and the study established a simple linear relationship between \(E_{TC}\) and maize yield was reported by Nimah et al., 1997).

Sivanappan (1974) reported 30-40% of water savings through irrigating 1 cm standing water upto flowering thereafter 2.5-3.5 cm standing water maintenance gave similar yield in rice than the conventional irrigation method with 5-10 cm standing water maintained throughout the crop period. Dabney and Hoff (1989) observed sprinkler irrigation at any level completely eliminated water stress in upland rice when potential evaporation was high.
Highest seed yield of 2.27 MT.ha\(^{-1}\) obtained in sunflower with frequent irrigation (18) at 40% ASM. in the top 30 cm layer of soil was reported by Kaliappa et al., (1974). Muriel et al., (1975) reported that the yield difference obtained under different treatments were not significant when irrigation given @ 100 & 75% of water equivalent to evapotranspiration. Though the yield was less when irrigation given at 50% of water equivalent to evapotranspiration, oil content was not affected in any of the treatments in sunflower. Sarkar and Bhattacharya (1980) recorded highest yield in sunflower with irrigation at 60% ASM. and frequent irrigation at 80% ASM. reduced the yield by 10%.

Sondge et al., (1992) reported seed yield of 1.79, 1.88 and 1.95 MT.ha\(^{-1}\) in safflower with irrigation @ 0.3, 0.6 and 0.9 IW:CPE level respectively against the yield of 1.2 MT.ha\(^{-1}\) under control (without irrigation) and the yield difference was not significant in different levels of irrigation.

Highest yield in cowpea with irrigation scheduled at 55% ASM. was reported by Surinder singh et al., (1975). In sweet pepper yield increase under drip, micro sprinkler and furrow irrigation methods by 168, 115 and 52% in winter and 186, 119.6 and 85% in summer respectively when compared to non-irrigated control plot. The NIR of 34.1 and 35.2 cm for winter and summer and the overall irrigation efficiency of 84, 65 and 37% under drip, sprinkler and furrow irrigation respectively were recorded by Goyal et al., (1987).

McHugh and Nishimoto (1980) reported in watercress sprinkler irrigation during summer season reduced the leaf temperature upto 4.8°C and increased the yield to about 80% than the yield obtained during cool season without sprinkling. However sprinkling had no effect on the leaf temperature, yield or quality of watercress growing in the cool season.
Production of 1.5 times more celery under drip irrigation with same amount of water used in furrow irrigation was reported by Hall (1982). In carrot, yield and economics under drip irrigation were 1.5 and 6.3 times higher than the sprinkler irrigation was recorded by Dematte et al., (1981). Maximum yield and 40% water saving with less weed growth in watermelon under drip irrigation when compared to overhead sprinkler irrigation was reported by Elmstrom et al., (1982).

In garlic, increased yield by 13.62 & 5% and increased WUE by 13.67% & 45.79% under sprinkler irrigation when compared to border irrigation @ 5 & 7 cm respectively were reported by Suryawanshi et al., (1986). EL-Gindy and EL-Araby (1996) reported that sub surface drip irrigation found more suitable for vegetable production in highly calcareous soils in terms of high yield and WUE.

Riter et al., (1984) estimated the requirement of water for maize, soyabean, peas, potatoes, lima beans, cucumbers, watermelons and tomatoes in Delmarva Peninsula as about 0.8 cm / day by calculating ETc using the solar radiation method.

In soybean maximum seed yield of 1.32 MT.ha.\(^{-1}\) with irrigation @ 0.6 IW:CPE throughout the growth stages was reported by Ramesh and Gopalsamy (1992) and Purushothaman et al., (1992) reported higher yield of 1.59 MT.ha.\(^{-1}\) with irrigation @ 0.75 IW:CPE applied in both rabi (winter) and Kharif (monsoon) season. However the WUE observed was highest under 0.6 IW:CPE irrigation.

Studies made by Sridhara et al., (1997) in soybean with different treatments on irrigation @ 0.4, 0.6, 0.8 value of CPE and moisture stress treatments through withholding irrigation for 15 days during flowering and or pod filling and with normal irrigation @ 0.8 value of CPE without any moisture stress. The results of the experiment revealed that the high seed yield, high protein and oil content recorded in treatments without moisture stress and reductions in seed yield, protein and oil content from normal irrigation treatment to moisture deficit during flowering + pod
filling by 34, 43, 34% and with moisture deficit during flowering alone by 22, 30, 12% respectively. Water stress at pod filling showed less effect than at flowering.

Similarly higher seed yield and water use efficiency was reported in summer moong (*Vigna radiata*) @ 0.4 IW:CPE irrigation application (Balyan and Malik, 1981). In loamy soil sprinkler irrigation with much less than estimated evapotranspiration (eET) water (10-15 cm) in beans (*Phaseolus vulgaris*) between full crop cover and harvest, the yield was not affected. In sandy soil, the yield was 24.8 MT.ha⁻¹ when irrigation given @ 14% of eET which increased to 50.4 MT.ha⁻¹ under 100% eET irrigation applied and it was also reported that the type of soil plays a vital role in deciding the amount of water requirement of crop (Miller and Burke 1983). Yield of black gram increases with increase in irrigation water (40mm IW/ irrigation) with IW:CPE @ 0.3, 0.5 and 0.7 was reported by Jayaraj (1987).

Studies on snap bean (*Phaseolus vulgaris*) with micro-sprinkler, drip & surface irrigation systems showed greater leaf area, larger numbers of trifoliate and greater number of nodes with the micro-sprinkler as compared to drip and conventional surface irrigation and the bean pod yield increased by 32 & 19% and water savings by 59 & 32% with drip and micro-sprinkler respectively when compared to surface irrigation (Tomar *et al.*, 1997).

### 2.1.5. OTHER HORTICULTURE CROPS:

Roth *et al.*, (1974) reported that drip irrigation increases growth of tree in orange and citrus compared to border and sprinkler irrigation and in date palms drip irrigation increased the leaf yield and bunch production was reported by Reuveni (1974). Root growth, fruit yield & size were better in addition to savings of about 2/3 water when compared to overhead irrigation in ‘Sunrich’ nectarines was reported by Bartholic and Buchanan (1976), similar effects in strawberries was reported by Locascio and Myers (1976). Drip irrigation in avocado was better in
terms of tree growth, leaf & soil analysis for nutrient level, wetting pattern and root
development and yield / acre inch water applied in different climatic factors when
compared to sprinkler irrigation (Gustafson et al., 1979).

Slack et al., (1980) reported 100% water reduction and better growth of tree
circumference & canopy surface and yield increase by about 141% with trickle
irrigation when compared to drag hose sprinkle irrigation in citrus. Cevik et al.,
(1982) reported 48, 31% water savings and 8, 4% fruit yield increase in drip
irrigation when compared to furrow and sprinkler irrigations respectively in citrus.
Studies made by Ozsan et al., (1983) in citrus revealed that the amount of irrigation
water applied was least (207mm) in drip and greatest in under tree irrigation and the
yield was highest with over tree sprinkler and least with furrow irrigation. Though
drip and sprinkler gave best quality fruits, WUE was highest with the former.

In grapes, drip and sprinkler irrigation @ 30-40% and 70% soil area wetted
respectively with 80 and 100% of total water requirement observed high fruit yield
in drip irrigation. Though 20% reduction in water application did not affected the
quality of fruits but the yield was reduced by 11% in drip and 13% in sprinkler
irrigated orchard reported by Bielorai (1982). Harbaugh et al., (1982) reported that
drip irrigation (35cm) in chrysanthemum gave linear response to fresh weight, dry
weight, leaf area, greatest number of marketable cut flowers and 91% reduction of
irrigation water compared to overhead sprinkler method of irrigation.

Fereres, et al., (1982) recorded higher water savings with drip than sprinkler
irrigation at the initial 2 years of establishment and after 5 years the water saving
difference under the two irrigation system was insignificant in almond. Irrigation
water equivalent to 60, 45 and 30% of Class A pan evaporation / week under drip
did not affected the fruit yield & quality and saved 60% of water when compared to
the traditional basin irrigation method in citrus was reported by Bosco et al., (1983).
Yagev and Horesch (1983) in a trial with marsh seedless grapefruit trees on sour orange rootstocks raised on clay loam soil, using drip and sprinkler irrigation @ 0.35, 0.47 or 0.60 of Class A pan evaporation, observed after 3 years found no yield difference between the two types of irrigation treatments. Under reduced water treatments the yield was less due to smaller fruits and lower juice content in treatment with drip. Nitrogen content of leaves in treatment under drip was higher than the treatments under sprinkler irrigation.

Kamber et al., (1986) observed higher yield in strawberry with 35% water saving in drip irrigation compared to furrow irrigation without significant effect on the fruit quality. In Ber tree (Ziziphus mauritiana) with an initial investment of Rs. 9000 acre\(^{-1}\) for drip irrigation achieved 30% water saving, 25% increased yield and income increased by 60%. Moreover weed growth and soil working was totally controlled in addition to 60% savings of fertilizer through fertigation (Patel, 1990).

Gu et al., (1982) reported that sprinkler irrigation in pears trees reduced temperature by 3.1\(^{\circ}\)C, RH increased by 12% in the orchard and rapid air convection increased CO\(_2\) conc. over the canopy. Absorbing capacity of roots and stomata opening increased by 8 and 0.1-0.55% respectively, rate of photosynthesis and single fruit weight by 3.5% and total yield increased by 13.2-13.7%.

Dahake et al., (1998) explained the perception of drip irrigation with two years experience by 100 orange growers in Akola district of Maharashtra on water, labour savings with increased productivity & returns for the benefit of stakeholders as a model for dissemination of technology through demonstration.

Better water relations and higher yield obtained in apple with sprinkler irrigation when compared to furrow irrigation was reported by Kushnirenko et al., (1975), however Vodyanitskii et al., (1980) recorded still high yield with drip when compared to overhead / under sprinkler irrigation in apple. Middletion et al., (1981)
reported water savings with drip irrigation in 7 years from planting was about 250% when compared to sprinkler irrigation and better growth early flowering, better yield coupled with quality were obtained in apple with drip irrigation when compared to sprinkler irrigation.

Thomas and Atkinson (1982) reported that trunk and root growth increased by 22.5 and 28% respectively in drip-irrigated apple garden which supported the observations already made by Vodyanitskii and Gorbach (1981). Pacholak and Przybyla (1995) reported increased yield upto 3.1 MT.ha\(^{-1}\) under soil water deficit conditions and with 3 times more WUE with drip irrigation when compared to crown irrigation in apple.

In Grape vine orchard better soil moisture distribution, well-adapted root system, highest yield and lowest mildew incidence was reported with drip irrigation when compared to sprinkler and furrow irrigation and water requirement under drip irrigation was observed less than 1/3 of that for furrow irrigation (Litvinov and Shevchenko (1978). Stevenson (1982) observed no difference on the growth and yield of 6-year-old vineyard when it converted from sprinkler to drip irrigation.

Better vegetative growth in brinjal under drip irrigation when compared to sprinkler irrigation was reported by Ranieri and Grossi (1972). Agarwal et al., (1975) reported maximum tuber yield and best size with increased WUE under sprinkler irrigation in potato. Richter (1975) and Tomar et al., (1976) reported maximum yield when irrigation given at 50-55% ASM. in mid-early potatoes, fodder beet, Lucerne and spring barley.

Stylianou and Orphanos (1981) reported that in semi arid region of Cyprus sprinkler irrigation equivalent to 0.7 - 0.8 of pan evaporation produced maximum yield whereas drip irrigation required 20% more water and cracking of the soil exposed tubers to attack by predator and hence not recommended for this region.
Tuber yield increase by 12% with 8% water savings was reported by Shalhevet et al., (1983) under drip system of irrigation when compared to sprinkler irrigation. Shatanawi (1987) reported higher root mass (in 100 mm of soil) and root length for better penetration (320 mm) during limited water supply in Victoria squash (*Cucurbita pepo*) to maintain the yield.

Geraldson (1973) reported that constant moisture provided by drip or by micropore tubing increased fruit yield in tomato by 8 kg / plant (projected to 310 MT.ha⁻¹) and this was supported by the studies made by Schweers and Grimes (1976). Maximum yield and WUE in brinjal was obtained at 45 mm CPE schedule irrigation by Umrani and Khot (1974) and yield increase of 67% in brinjal obtained under drip irrigation compared to furrow irrigation was reported by Vieira and Manfrinata (1974). Bryan et al., (1976) reported yield increase in many vegetables, including tomato and beans under drip when compared to overhead irrigation.

Better maintenance of soil moisture with low water tension throughout the growing period under drip irrigation, which influenced yield increase and quality for processing of tomatoes (Rudich et al., 1977). Whereas 27.8% increased fruit yield with 49.5% water saving under drip irrigation when compared to furrow irrigation was reported by Channappa (1979). Ben-Asher (1979) reported higher fruit yield in tomato with drip irrigation adapted to avoid deep percolation of water in sandy / low water holding capacity soil when evaporative ability of atmosphere was at its peak measured with US Class A pan evaporation.

About 54% water savings without affecting the yield in tomato under drip irrigation when compared to furrow irrigation was recorded by Doss et al., (1980). In tomato maximum fruit yield of 80 MT.ha⁻¹ at lower irrigation level equal to 40% value of Epan from a US Class A pan evaporimeter was reported by Kafkafi and Bar-Yosef (1980). With a total amount of 1.0 acre inch irrigation water applied with drip 40 and 27% increased yield in tomato and capsicum respectively when
compared to non-irrigated plantations in a relatively wet season was reported by O'Dell (1983).

Lin et al., (1983) reported 20-40% more marketable fruit yield in tomato with drip irrigation in different level soil moisture maintenance between 25-80%. Plots with 25% ASM. also produced similar fruit yield but for fewer non-marketable fruits with 30% less water than furrow irrigated plots. Ghukwuma (1988) recommended irrigation at 50% ASM. for optimum use of limited water supplies in the dry season in vegetables and seed production.

Comparison of drip irrigation (with different emitters) vs. furrow irrigation in tomato with plant spacing of 35, 50 and 70 cm. in deep clay loam soil in rain free season showed that higher yield with drip irrigation and no significant difference in yield between the emitters and plant spacing and irrigation interaction in terms of fruit size, plant height & WUE were greater in drip (Yohannes and Tadesse, 1998).

Studies made by Pratapsingh et al., (1990) in tomato crop raised in sandy loam soil, irrigated with saline and canal good water at the rate of 5 or 6 cm. / irrigation revealed higher fruit yield at 0.5 IW:ETP compared to other ratio with surface irrigation. The yield was better in drip irrigation used with saline water and surface irrigation with canal water. When the water table was shallow the surface irrigation performed better.

Jadhav et al., (1990) reported tomato fruit yield of 48 MT.ha$^{-1}$ with drip irrigation as against 32 MT.ha$^{-1}$ under furrow irrigation with cost benefit ratios 5.15 and 2.96 respectively by utilizing 31 % irrigation water saved in an additional 0.4 ha. area and reduction in expenditure on labour requirement in with drip irrigation compared to furrow irrigation.

Drip irrigation scheduled at alternative day @ 79% of ET value and fertigation @ 96% of recommended dose resulted maximum yield increase up to
27% and water saved up to 21% and with improved mechanical drip set water saving was achieved up to 50% in tomato by Dalvi et al., (1999).

Sivanappan et al., (1974) reported that 84.7% water saving under drip irrigation compared to conventional furrow irrigation without any adverse effects on growth and yield in bhendi and this was confirmed by Sivanappan (1979) in several vegetable crops like tomato, capsicum, okra, pawpaw and bananas with drip irrigation when compared to conventional surface irrigation at 50% SMD. Further it was reported that weed growth was under control in drip irrigation.

In sugar beet 55% increased yield and 79% water savings was recorded by Sivanappan and Chandrasekaran (1976) in drip irrigation when compared to surface irrigation. Sugar beet crop raised on a loamy sand soil of low water retention capacity with irrigation schedule of 30-30-45 mm CPE in three growth stages tested with different schedules upto 60mm CPE was reported that the highest yield of 44.1 MT.ha⁻¹ roots & 6.83 MT.ha⁻¹ sugar and WUE of 912 kg roots/cm (Bains and Narang, 1988).

2.2. SOIL REGIME AND MULBERRY GROWTH:

Quality mulberry leaf possesses all nutrition required for better growth of silkworm to form quality cocoon is adjudged by the better growth of mulberry from good soil supplied with adequate inputs. A good soil is said to be rich in organic residue (humus) with colloidal fraction, better water holding capacity, aeration and micro flora for bio-degradation and soil health maintenance plays a vital role for better productivity in mulberry.

Mulberry responds extremely well to fertilizer inputs at optimum soil moisture (Chung et al., 1980). Deep, fertile, well-drained, friable, porous, clayey loam to loamy soil, slightly acidic (6.2 to 6.8 pH) are ideal for mulberry growth (Chandrasekhar and Thangavelu, 1988). Soil with crumb structure having higher
microbial activity, cation exchange and organic matter content, sufficient moisture and pH in the range of 6.5-7.5 is ideal for optimum growth of mulberry and nutrients from the soil in dissolved state are well utilized by mulberry plant when sufficient moisture is maintained in the soil (Subbaswamy et al., 1994).

The importance of soil testing before planting mulberry and periodical analysis of soils of the established mulberry garden were emphasized by Prakash C. Bose (1988); Mukund Kirsur (1997) and Ogra (2000) to maintain the soil health in optimum conditions through corrections for better growth of mulberry plants and sustainable productivity in different regions based on the variations in soil qualities from place to place and site to site.

Deep and repeated ploughing in mulberry garden before monsoon and covering the exposed soil with paddy straw / dry weed during dry season check the growth of weeds, retains soil moisture and prevent surface evaporation of water was reported by Prasad et al., (1993).

Bose and Mujumdar (1995) reported that soil amendments with FYM, press mud, gypsum or sulfur in mulberry grown in sodic soil increased the leaf productivity and improved the economics. Maximum increase was obtained from the garden amended with sulfur. FYM and sulfur increased the moisture content of mulberry shoots and the importance of assured irrigation, well drained, clay loam to loamy, deep, fertile and light textured soil with pH 6.2 to 6.8 for mulberry cultivation under sub tropical conditions were emphasized by Bindroo et al., (1996).

Plant spacing in mulberry garden ranging from close to wider spacing of 90cm x 90cm (popular) and (60cm + 90cm) x 150cm (recent introduction) to facilitate mechanization at big farmers’ level in Tamil Nadu state for productivity maintenance was reported by Gangwar and Thangavelu, 1994.
Application of Irrigation water in mulberry garden in alternate furrow, avoiding bottom pruning during summer months, application of more organic manure increase soil moisture during summer (Mishra et al., 1997). Subbaswamy et al., 1998 reported that soil fertility changes in mulberry gardens are time dependent and influenced by the cropping pattern and fertilizer usage by mulberry plants.

2.3. MULBERRY LEAF QUALITY AND SILK PRODUCTION:

The nutritional status of mulberry leaves which influences the economic characters of silkworm crop depends upon the level of moisture, total protein, total carbohydrates and total minerals found in mulberry leaves (Bongale et al., 1991). Machii and Katagiri (1991 reported that the status of nutrition in mulberry leaves plays very important role during the early stages of larval growth and increase of cocoon production per unit area of mulberry garden which is mainly influenced by the quality linked increased leaf productivity in a unit area and this was supported by the studies conducted by Bongale et al., (1997).

Leaf quality refers to the nutritive value of mulberry leaf which influences better growth of silkworm larvae, quality cocoon and raw silk production was reported by Krishnaswami et al., (1970) and the same was supported by different authors in later period (Ito, 1978; Bari et al., 1985; Machii and Katagiri, 1990; Sarkar and Fujita, 1994). Protein level of 20 to 25% in mulberry leaves is required for better growth of silkworm larvae and synthesis of silk proteins (Horie, 1978).

Importance of moisture content of leaves in mulberry and its vital role in improving the nutritional value of leaves, which in turn improve the palatability and digestibility and growth rate of silkworms was discussed by several authors since 1960s [Ito, 1963; Uedo and Suzuki, 1967; Parpiev, 1968; Waldbaur, 1968; Kasiviswanathan et al., 1973; Sikdar, 1990; Machi and Katagiri., 1990 and Sujathamma and Dandin 2000].
High moisture content and its retention capacity of leaves help to remain fresh for longer time acceptable to silkworms are related to thickness of leaves which in turn due to the ratio of palisade to parenchyma cells found in leaves were recorded by Hesketh et al., (1985).

Size of the stomata & its frequency’s role in moisture retention, transpiration and CO₂ exchange rate was discussed by Susheelamma and Jolly (1986). And preservation of mulberry shoots in bundles in vertically upright position with foliage covered with wet gunny cloth and cut ends in dipped in water and utilized in shoot rearing system increased the growth of larvae and better cocoon yield was reported by Khan et al., (2003).

About 22 gm of mulberry leaves are ingested by a silkworm during its entire larval period, of which about 90 % is ingested during the final stage (5\textsuperscript{th} instar) was recorded by Hiratsuka (1917) and carbohydrate in mulberry leaves are utilised as energy source for body building purpose and for synthesis of lipids and amino acids by silkworms are discussed by Hiratsuka (1917) and Horie (1978).

Fukuda (1951) reported that about 63 % of mulberry leaf protein ingested by the silkworm is digested. Of this about 50 % is utilised for synthesis of silk protein. During 5\textsuperscript{th} instar, the protein synthesis in other than silk glands declines from 64 % to 4 % whereas in silk gland cells it increases from 9% to 96 % from this it is clear that the silkworm larvae in the 5\textsuperscript{th} instar convert the mulberry protein into silk protein with an amazingly efficient manner.

2.4. IRRIGATION SYSTEM IN MULBERRY CULTIVATION:

Mulberry belongs to the genus Morus of family Moraceae. It grows in different types of soil under varied agro climatic conditions. However establishment of mulberry garden is well in soil with pH range from 6.5 to 7.5, EC < 1.0 DSm⁻¹,
adequate spacing for optimum number of plant population and supply of recommended doses of organic manure @ 25 MT (FYM / Compost) and chemical fertilizers N:P:K @ 300-350:120-140:120-140 kgs.ha⁻¹.year⁻¹ (Dandin et al., 2005 and Rajaram and Rajan, 2008).

Irrigation water requirement for mulberry equal to the value of cumulative pan evaporation (CPE) of open US Class A pan evaporation scheduled at 50% ASM was recommended by Naoi (1975, 1977).

Drip and sprinkler irrigation save an average of 33% water over the conventional furrow irrigation without affecting the leaf yield with improvement in leaf moisture was reported by Saratchandra (1990).

Maximum leaf yield and additional mulberry area coverage under irrigation by utilizing the water saved in drip irrigation was reported by Gopinath (1994). The cost benefit ratio in drip and furrow irrigation in mulberry of 1.64 and 2.37 respectively was reported by Muralihara et al., (1994)

Ananthakrishna et al., (1995) reported 48% more leaf yield and 67% water savings with drip irrigation equal to 40% CPE from open class A pan evaporimeter applied. However irrigation @ 80% of CPE value with 33% water saving under drip irrigation was found to be optimum for mulberry over conventional furrow method.

Studies conducted in K₂ by Mishra et al., (1995, 1996 and 1997) revealed that the leaf yield of 36590 and 31482 kgs.ha⁻¹.yr⁻¹ with furrow irrigation at CPE value 47 and 70 mm under 3' x 3' and 2' x 2' spacing respectively and 38793 and 38433 kgs.ha⁻¹.yr⁻¹ under drip irrigation at 80% and 60% of CPE value respectively with 40% water saving in K₂ under 2' x 2' spacing. In addition to water savings higher leaf moisture content, nutrient value and leaf yield were recorded.
Benchamin et al., (1997) reported that the existence of positive correlation between the leaf yield and the quantum of irrigation water applied and frequency of irrigation in Kanva 2 mulberry variety. Drip and sprinkler irrigation save 33 % of irrigation water without loss of leaf yield and quality compared to ridges and furrow method and also found that the drip system was more efficient with 10.3 to 14.5% increased leaf yield over furrow system under any quantum of irrigation treatment. Sprinkler system was also found efficient over furrow irrigation system and suitable for undulated, sloppy terrain land and prevention of soil erosion in mulberry garden. Above all the response of mulberry crop to water in terms of productivity increase by 300 to 400% when compared to rainfed condition and amazing adaptability of mulberry to different levels of soil moisture stress were also discussed.

Studies of Rama Kant et al., (1998) revealed high moisture around main root zone through limited water supply, reduced percolation loss of water; application of water-soluble fertilizers through drip saves 30 to 40 % of fertilizer and save man power requirement in mulberry cultivation and Mallikarjunappa et al., (1998) in a separate study recorded maximum leaf yield under 6 crops / year in leaf harvest and 5 harvest / year with shoot harvest method. Gradual reduction in yield observed when frequency of shoot harvest increases. Maximum leaf yield without affecting the nutritional quality with 30% saving of water was obtained under drip irrigation @ 4 lr. / plant in alternate days in K2 mulberry (Magadum et al., 2004).

The Production function analysis indicated that fertilizer and irrigation were the two factors, which played major role in increasing mulberry output in Salem district in Tamil Nadu (Lakshmanan et al., 1997).

Drip irrigation saves maximum of 44.56 % water with 15% increased leaf yield without affecting the quality of leaves, besides 25% saving in N and K fertilizers through fertigation in V1 mulberry (Arunadevi, 2006).
HYDROLOGICAL CYCLE
(Water Resources & Utilization in India)

37,00,000 (m cu m)
[Thru' Precipitation @ 112CMs/Annun]

8,00,000 (21.62)
(Seep into ground)

17,00,000 (48.95)
(Surface flow)

12,00,000 (32.43)
(Evap. back to atmos.)

4,30,000 (11.62)

6,66,000 (18.00)
(Utilizable by crops)

3,70,000 (10.00)

55,740 (1.51)
(Ground water annual recharge)

2,69,960 (7.30)
(Groundwater annual recharge)

2,460 (0.07)
(poor saline reg.)

2,67,500
(Net Groundwater annual recharge)

2,03,600
(75-80 of Net GW recharge) (5.50)
as Net GW Pot. for crop util.

5,55,00,000 (Gross GWR)

Fig. in parenthesis denotes %.